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PLANT PHYSIOLOGY FOR THE HIGH SCHOOL.

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The present paper is intended as an introduction to a series of articles on plant physiology for the High School, which I hope to contribute to SCHOOL SCIENCE, not in consecutive numbers, but from time to time as they are completed. I propose to take up each of the topics in plant physiology which are so fundamental that they should be treated in a high school course, and I shall omit all others. Under each topic I shall endeavor to give a clear exposition of its importance and general bearings, with the principal facts about it; a description of the best apparatus and methods known to me for demonstration, for individual student work and for makeshift, with practical directions for the use of each, and warnings for the avoidance of common errors; a discussion of the correct physics and chemistry of each subject, and of the theories to account for the phenomena; a treatment of good pedagogical methods of handling the subject; and a summary of its bearings upon the other phenomena of plant and animal life, especially upon the structures and adaptations of plants.

The thoughtful reader will at once ask how I am to decide upon the topics to be selected for such treatment, or in other words, how in the face of much probable difference of opinion upon

the subject I am to decide which topics are fundamental in an elementary course. In answer I would say that I shall take those topics which have been recommended in the most authoritative document which at present exists upon the subject—the Standard Course formulated by the Committee of the Society for Plant Morphology and Physiology and published in this journal in May, 1902. The physiological topics as there recommended, and as they will be treated in this series (though not necessarily in this order) are the following, those requiring experiments being in italics:

Role of water in the plant; *absorption (osmosis), path of transfer, transpiration, turgidity and its mechanical value, plasmolysis.*

Photosynthesis; *Dependence of starch formation upon chlorophyll, light and carbon dioxide; evolution of oxygen,* observation of starch grains.

Respiration; *necessity for oxygen in growth, evolution of carbon dioxide.*

Digestion; *Digestion of starch with diastase,* and its role in translocation of foods.

Irritability; *Geotropism, heliotropism* and *hydrotropism;* nature of stimulus and response.

Growth; *localization in higher plants; amount in germinating seeds and stems; relationships to temperature.*

Fertilization; sexual and vegetative reproduction.

I. INTRODUCTION.

There are many differences between the older and the newer botanical instruction, but the greatest of these is the presence in the newer of much plant physiology. Whether one views the modern textbooks, or the courses in the more advanced institutions, or recent educational discussions—it is everywhere the same, a strong emphasis upon plant physiology as an integral part of every truly scientific elementary course in botany.

That the emphasis upon this phase of the science is no passing whim, but a permanent addition to scientific education,

there is every evidence. Its growth has been gradual and sound, and it has won recognition as an indispensable foundation for an understanding not only of plant structure and adaptations, but also of the simpler processes of animal physiology, as illuminating and pleasing knowledge, and as a peculiarly valuable intellectual discipline, one going far towards aiding to elevate botany to as high an educational rank as any subject possesses. It is now safe to say that every progressive and well-informed high school teacher either already has introduced a fair proportion of the subject into his instruction, or else is preparing to do so.

To secure its full educational value, however, there is one great prerequisite, namely that it shall be taught in the truly scientific inductive spirit from actual personal observation and logical experiment. This phase of the subject has been treated by Professor Barnes in the December (1902) number of this journal, and I am so fully in agreement with him, that his article might well form a part of the introduction to the present series. As to the solution of the practical difficulties of teaching this subject to large classes, I have offered some suggestions, based upon a considerable personal experience, in the February (1902) number of this journal. By far the best way is to have all experiments performed by each student individually, but as that is generally impossible in high schools, a fair substitute consists in making each student a participant in the experimenting, holding him responsible for as full an understanding and exposition of each experiment as if it were actually carried out by himself individually. As the aforementioned articles are, no doubt, generally accessible to my present readers, I need not here repeat their recommendations.

The understanding of plant physiology is by no means easy, but this is precisely one of its chief educational values. Moreover, the teacher should by no means attempt to select its easiest, but its most important parts. It is far better that the pupil should attack those questions which the nature of the subject points out as most fundamental and illuminating, and do the best he can with them, than that he should concern himself with matters of lesser importance even though these are easier to study and more open to simple experiment. I do not believe at all that this, or any

other subject, should be used for the primary purpose of giving training in observation, etc. (those parts of it being selected which approve themselves as best for this purpose), but I hold that each subject should be studied primarily for its own sake, and with the attention directed first of all to its true proportions and its distinctive methods. This not only puts the study upon a much higher plane, but the training in observation, reasoning, etc., incidentally gained is much greater than if these are made a primary object in themselves. After all, these things in education are a means to an end, not an end in themselves. While I believe that hard or easy, the important phases of any subject should be courageously attacked, it certainly is a very happy circumstance that none of the fundamental topics of plant physiology are beyond the grasp of the average high school student if properly led by a competent teacher. In our high specialization of methods, and our extension of the elective system, we are too prone to regard the student's inclination as the test of the value of a subject to him, losing sight of the value of effort in education and of its necessity in a training for achievement.

The proportional amount of attention that plant physiology should receive in an elementary course in botany is correctly represented, I believe, in the Standard High School Course formulated by a Committee of the Society for Plant Morphology and Physiology, and published in the May (1902) number of this journal, to which the reader is recommended to refer. As to the proper, or ideal, place for a course in botany involving this amount of physiology, I believe it should come as late in the high school course (or as early in the college course) as possible. It is very desirable that it shall be preceded by some instruction in chemistry and physics, though this is not indispensable, especially if the pupils have been taught, as they should be, the elemental facts and processes of nature through nature study in the lower schools.

Until very recently plant physiology could not be taught generally in elementary courses for three reasons; properly trained teachers were not obtainable; there were no books suitable as guides for either teachers or pupils; and the needful apparatus was costly, and cumbersome to manipulate. All of these difficulties have been in large part overcome. Many of our good colleges are

sending out graduates well trained to teach this subject; several good books, adapted especially to the conditions prevailing in our schools, have been published; and apparatus has been simplified and cheapened to an extent allowing its purchase and use by all.

The books useful as guides in elementary plant physiology are the following.* Most of the recent elementary textbooks contain directions upon simple experimenting, and these directions are particularly practical in Professor Barnes' *Plant Life.* There are two books devoted specifically to simple experimenting in plant physiology, MacDougal's *Elementary Plant Physiology,* and my own *Laboratory Course in Plant Physiology.* Neither of these is a textbook of physiology, for which one should turn to MacDougal's larger work—*Practical Text Book of Plant Physiology,* which is a combined laboratory guide and textbook. The best modern reading book on the subject is J. Reynolds Green's *Introduction to Vegetable Physiology,* but Noll's *Physiology* in Strasburger's Textbook is also good. A new work by Peirce, just announced as ready for publication, is of this kind. Of more elaborate books of laboratory directions the standard is Moor's translation of Detmer's well-known *Practical Plant Physiology,* an admirable work, more extensive than the elementary teacher is likely to use but invaluable for reference; and of much value, too, is Darwin and Acton's *Practical Physiology of Plants.* Of reference works the great standard is Ewart's translation of Pfeffer's work, entitled *The Physiology of Plants,* a new and invaluable handbook of physiological fact by the greatest living master of the subject. It is too exhaustive and too technical for the use of elementary students, but indispensable to the progressive teacher. There are other useful works, especially including the *Lectures* of Sachs and of Vines (now out of print) which may be found described in the bibliography of my book above mentioned, but those here cited are the most important to our present subject.

The publishers and prices of the works cited in this paragraph are:—Barnes, Plant Life, Holt & Co., $1.12; Ganong, Laboratory Course, Holt & Co., $1.00: MacDougal, Elementary Plant Physiology, Longmans, Green & Co. $1.20 and his Practical Text Book, Longmans, Green & Co., $3.00; Green's Introduction, Churchill (London) 10s. 6d.; Strasburger's Text Book, Macmillan, $4.50; Peirce's work is to be published by Holt & Co.; Detmer-Moor, Practical Plant Physiology, Macmillan Co., $3.00; Darwin and Acton, Practical Physiology, Cambridge, England, 4s. 6d.; Pfeffer-Ewart, Physiology, Clarendon Press, Oxford, Vol. I, 28sh. (Vol. II not yet ready.)

The apparatus described in the works by MacDougal and by myself has been so simplified that most of the necessary materials and appliances may be bought from any Supply Company, or manufacturerd from materials easily obtainable. Curiously enough the direction taken in this country in the simplification of appliances has been almost entirely towards the utilization of apparatus and mechanisms already developed for other purposes, and there has been but little new apparatus specifically designed for work in plant physiology manufactured and offered for sale,* nor has any firm in this country yet made a specialty of supplying materials needed for the subject. Not much more is to be expected from the adaptation of existing appliances, and it is desirable now to develop moderately accurate and moderately-priced apparatus for this express purpose. I have myself designed a number of pieces of such apparatus, and have prepared lists of materials needed in elementary plant physiology; and negotiations are in progress which will enable me, I trust, to announce, before this series of articles has proceeded very far, that specially made apparatus and all needful minor supplies may be purchased at reasonable cost from a responsible firm in this country. Apparatus may be classified into four groups: First, there is that for *investigation,* which must be the most accurate that can be made; this is usually costly and difficult of manipulation, and hence of only secondary interest to the teacher of elementary courses. Second, there is that for *demonstration,* by which the fundamental processes may be clearly, logically and conveniently demonstrated to large classes; this is of primary importance where facilities are not available for individual student work, and in any case, a collection of it has much value. Third, there is that for *individual student work,* necessarily much simpler than the preceding, but capable of being made to give fairly accurate results; this is the most valuable of all where facilities for individual work are available, and that which the teacher should endeavor to obtain as far as possible. Fourth, there is *make-shift apparatus,* constructed from easily accessible and inexpensive materials, which everybody can afford and obtain; it is

* Practically the only exception is the several excellent pieces made and sold by Professor J. C. Arthur, Purdue University, Lafayette, Indiana.

valuable if it gives the correct *kinds* of results, even though these be quantitatively inaccurate.

There is another question connected with apparatus which will here occur to the reader, namely, whether this experimental work can be carried on without a greenhouse. Certainly the greenhouse is desirable, and, for all advanced work, indispensable; but for the experiments here in question it is not necessary, though some form of Wardian case, adapted to keep the plants to some extent under greenhouse conditions, is needed*.

Other practical points in connection with the subject will be treated in their appropriate places later in the series.

HIGH SCHOOL BOTANY.

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Botany is the unsettled study in our high schools today, and is likely to remain so until it is taught from the standpoint of the practical in education. Educators do not seem able to agree as to what should constitute the course in botany, and largely for the reason that they have not recognized the needs of the schools, but have been trying to bring them above themselves into the realm of the technical and exact before they are ready for it. One thing has been agreed to and that is that the old form of botany teaching was nothing more than "book larnin', which is true enough. This kind of teaching has been discarded as worthless, and the clamor has been to study plants and not books. This is all well enough, but along with the change has come a condition which is little better than the old. Simply to study plants is not enough. There should be a purpose in that study. Particular plants should be studied because they are worth knowing about, and particular facts should be studied about these plants because they have a bearing upon our lives. "Learning those

* I have discussed the subject of Wardian Cases and their cost in my "Teaching Botanist," pages 82-85.

things in nature that are best worth knowing, to the end of doing those things that make life most worth living" is the purpose in nature study as expressed by Clifton F. Hodge, and it applies as well to botany.

Botany today, in most high schools, is nearly as unsatisfactory as formerly. Many textbooks have been written, and many courses mapped out, and still our pupils are wasting time in studying botany. The fault has been with nearly all of these courses that botany has been treated from the standpoint of the college and university, and not from the standpoint of the high school. They have not taken into account the mental stock in trade of the high school pupil, nor have they recognized the fact that the high school is the "people's college," and that the botany taught here should be for the pupil who does not go to college, as well as for the pupil who does go to college. As now taught it is too scientific and too exact for the needs of the high school. Says L. H. Bailey: "Education should train persons to live, rather than to be scientists." Hence we would learn that botany should be made more practical, nearer the life and needs of the child of high school age. What the public demands, and rightly so, is high school botany in the high school, and not the ridiculous attempt at teaching college botany in the high school, and that, in most cases, by teachers unfit for the work.

In most other studies we have well graded courses leading gradually from the simple to the complex, from the known to the unknown, from the concrete to the abstract, from the general to the particular, from that which is a part of the child's every day life to life in foreign lands, and in all of these there is an attempt made to keep close to the human element, and to that which has a place in the complete development of the child. In most studies we adhere to the law that the mind must struggle with problems which are within its range. The child should have that which is fitted to his mind at a particular stage of mental development just as truly as he should have a suit of clothes to fit his body at a particular stage in his physical development. Apart from the fitting of the subject to the child, there is the natural sequence to the matter of the subject which must be recognized in planning any course. There are always topics which

are elementary and should be learned first, and topics which are advanced and should be learned later. To reverse this order is a positive harm, or, to say the least, is a waste of time.

In the case of botany much of this is disregarded. There appears to be very little attempt at gradation. From the very first day the pupil, upon taking up high school botany, is plunged into a study of the minute parts of plants. In some cases he is started with a compound microscope placed before him. He is given sections to study which have been prepared for him. In the very nature of the case he cannot understand where they came from or what they really represent. He has not a wide enough acquaintance with plants, has not a sufficient botanical setting to comprehend what he is attempting. Even if he has acquired a wide acquaintance with plants before coming to the study of botany in the high school his mind is too immature for this exact and technical work.

Botany in the high school must of necessity be elementary. However, this does not mean that it must be made easier, but that the work must be confined to topics which are within the range of the pupil's understanding. To attempt to teach botany from the standpoint of the university in the high school satisfies neither the demands of the great majority who never go beyond the high school, nor the few who go to college. In the first instance, the pupil who finishes his education with the high school has no use for the knowledge acquired by the study of the minute structure of plants, or the advanced problems in the subject, except so far as they are within his mental range and at the same time have some human value. What he needs in the way of knowledge and discipline to be of any practical value to him is knowledge and discipline which will enable him to recognize the various trees, shrubs, and herbs in his locality, and to know of their value or harm to mankind; knowledge which will tell him of the habits of these plants, where they live, how they live, what conditions are beneficial and what are not; knowledge relating to the economic value of plants, what plants are of economic value, how they grow and where they grow best, what soils they are best suited to, what their enemies are and how these enemies are recognized by man and subdued. In a word, there is a vast field of botany to be studied

which will put the student into close relationship with his surroundings, and which can be studied with very inexpensive apparatus. This is a large enough field to occupy the entire time given to botany in any high school. It will take the pupil into the woods and fields to get his knowledge, as far as possible, first hand, rather than confining him to a study of prepared specimens in the laboratory, of the habits and habitats of which he has and can get very little or no knowledge. One might as well study about a city without knowing where it is located or what its relationship to other geographic knowledge is, or the details of events in a certain period of history without knowing its date or where it fits into the framework of history.

(*Concluded in March.*)

VARIOUS LOW-TEMPERATURE RESEARCHES.*

BY JAMES DEWAR.

We may now summarize some of the results which have been attained by low-temperature studies. In the first place, the great majority of chemical interactions are entirely suspended, but an element of such exceptional powers of combination as fluorine is still active at the temperature of liquid air. Whether solid fluorine and liquid hydrogen would interact, no one can at present say. Bodies naturally become denser, but even a highly expansive substance like ice does not appear to reach the density of water at the lowest temperature. This is confirmatory of the view that the particles of matter under such conditions are not packed in the closest possible way. The force of cohesion is greatly increased at low temperatures, as is shown by the additional stress required to rupture metallic wires. This fact is of interest in connection with two conflicting theories of matter. Lord Kelvin's view is that the forces that hold together the particles of bodies may be accounted for without assuming any other agency than gravitation or any other law than the

* Part of the address of the President of the British Association for the Advancement of Science delivered in Belfast, Ireland, September, 1902.

Newtonian. An opposite view is that the phenomena of the aggregation of molecules depend upon the molecular vibration as a physical cause. Hence, at the zero of absolute temperature, this vibrating energy being in complete abeyance, the phenomena of cohesion should cease to exist, and matter generally be reduced to an incoherent heap of cosmic dust. This second view receives no support from experiment.

The photographic action of light is diminished at the temperature of liquid air to about twenty per cent. of its ordinary efficiency, and at the still lower temperature of liquid hydrogen only about ten per cent of the original sensitivity remains. At the temperature of liquid air or liquid hydrogen a large range of organic bodies and many inorganic ones acquire under exposure to violet light the property of phosphorescence. Such bodies glow faintly so long as they are kept cold, but become exceedingly brilliant during the period when the temperature is rising. Even solid air is a phosphorescent body. All the alkaline earth sulphides which phosphoresce brilliantly at the ordinary temperature lose this property when cooled, to be revived on heating; but such bodies in the first instance may be stimulated through the absorption of light at the lowest temperatures. Radio-active bodies, on the other hand, like radium, which are naturally self-luminous, maintain this luminosity unimpaired at the very lowest temperatures, and are still capable of inducing phosphorescence in bodies like the platino-cyanides. Some crystals become for a time self-luminous when cooled in liquid air or hydrogen, owing to the induced electric stimulation causing discharges between the crystal molecules. This phenomenon is very pronounced with nitrate of uranium and some platino-cyanides.

In conjunction with Professor Fleming, a long series of experiments was made on the electric and magnetic properties of bodies at low temperatures. The subjects that have been under investigation may be classified as follows: "The Thermo-Electric powers of Pure Metals;" "The Magnetic Properties of Iron and Steel;" "Dielectric Constants;" "The Magnetic and Electric Constants of Liquid Oxygen;" "Magnetic Susceptibility."

The investigations have shown that electric conductivity in pure metals varies almost inversely as the absolute temperature

down to *minus* 200 degrees, but that this law is greatly affected by the presence of the most minute amount of impurity. Hence the results amount to a proof that electric resistance in pure metals is closely dependent upon the molecular or atomic motion which gives rise to temperature, and that the process by which the energy constituting what is called an electric current is dissipated essentially depends upon non-homogeneity of structure and upon the absolute temperature of the material. It might be inferred that at the zero of absolute temperature resistance would vanish altogether, and all pure metals become perfect conductors of electricity. This conclusion, however, has been rendered very doubtful by subsequent observations made at still lower temperatures, which appear to point to an ultimate finite resistance. Thus the temperature at which copper was assumed to have no resistance was *minus* 223 degrees, but that metal has been cooled to *minus* 253 degrees without getting rid of all resistance. The reduction in resistance of some of the metals at the boiling point of hydrogen is very remarkable. Thus copper has only one per cent, gold and platinum three per cent, and silver four per cent of the resistance they possessed at zero C., but iron still retains twelve per cent of its initial resistance. In the case of alloys and impure metals, cold brings about a much smaller decrease in resistivity, and in the case of carbon and insulators like gutta-percha, glass, ebonite, etc., their resistivity steadily increases. The enormous increase in resistance of bismuth, when transversely magnetized and cooled, was also discovered in the course of these experiments. The study of dielectric constants at low temperatures has resulted in the discovery of some interesting facts. A fundamental deduction from Maxwell's theory is that the square of the refractive index of a body should be the same number as its dielectric constant. So far, however, from this being the case generally, the exceptions are far more numerous than the coincidences. It has been shown in the case of many substances, such as ice and glass, that an increase in the frequency of the alternating electromotive force results in a reduction of the dielectric constant to a value more consistent with Maxwell's law. By experiments upon many substances, it is shown that even a moderate increase of frequency brings the large dielec-

tric constant to values quite near to that required by Maxwell's law. It was thus shown that low temperature has the same effect as high frequency in annulling the abnormal dielectric values. The exact measurement of the dielectric constant of liquid oxygen, as well as its magnetic permeability, combined with the optical determination of the refractive index, showed that liquid oxygen strictly obeys Maxwell's electro-optic law even at very low electric frequencies. In magnetic work the result of greatest value is the proof that magnetic suceptibility varies inversely as the absolute temperature. This shows that the magnetization of paramagnetic bodies is an affair of orientation of molecules, and it suggests that at the absolute zero all the feebly paramagnetic bodies will be strongly magnetic. The diamagnetism of bismuth was found to be increased at low temperatures. The magnetic moment of a steel magnet is temporarily increased by cooling in liquid air, but the increase seems to have reached a limit, because on further cooling to the temperature of liquid hydrogen hardly any further change was observed. The study of the thermo-electric relations of the metals at low temperatures resulted in a great extension of the well known Tait thermo-electric diagram. Tait found that the thermo-electric power of the metals could be expressed by linear function of the absolute temperature, but at the extreme range of temperature now under consideration this law was found not to hold generally; and, further, it appeared that many abrupt changes take place, which originate probably from specific molecular changes occurring in the metal. The thermo-electric neutral points of certain metals, such as lead and gold, which are located about or below the boiling point of hydrogen, have been found to be a convenient means of defining specific temperatures in this exceptional part of the scale.

The effect of cold upon the life of living organisms is a matter of great intrinsic interest, as well as of wide theoretical importance. Experiment indicates that moderately high temperatures are much more fatal, at least to the lower forms of life, than are exceedingly low ones. Professor McKendrick froze for an hour at a temperature of—182° C. samples of meat, milk, etc., in sealed tubes; when these were opened, after being kept at blood heat for a few days, their contents were found to be quite

putrid. More recently some more elaborate tests were carried out at the Jenner Institute of Preventive Medicine on a series of typical bacteria. These were exposed to the temperature of liquid air for twenty-four hours, but their vitality was not affected, their functional activities remained unimpaired, and the cultures which they yielded were normal in every respect. The same result was obtained when liquid hydrogen was substituted for air. A similar persistence of life in seeds has been demonstrated even at the lowest temperatures; they were frozen for over a hundred hours in liquid air, at the instance of Messrs. Brown and Escombe, with no other result than to affect their protoplasm with a certain inertness, from which it recovered with warmth. Subsequently, commercial samples of barley, pea, vegetable marrow, and mustard seeds were literally steeped six hours in liquid hydrogen at the Royal Institution, yet when they were sown by Sir W. T. Thiselton Dyer at Kew in the ordinary way, the proportion in which germination occurred was no less than in the other batches of the same seeds which had suffered no abnormal treatment. Bacteria are minute vegetable cells, the standard of measurement for which is the "mikron." Yet it has been found possible to completely triturate these microscopic cells, when the operation is carried out at the temperature of liquid air, the cells then being frozen into hard breakable masses. The typhoid organism has been treated in this way, and the cell plasma obtained for the purpose of studying its toxic and immunizing properties. It would hardly have been anticipated that liquid air should find such immediate application in biological research. A research by Professor Macfadyen, just concluded, has shown that many varieties of microorganisms can be exposed to the temperature of liquid air for a period of six months without any appreciable loss of vitality, although at such a temperature the ordinary chemical processes of the cell must cease. At such a temperature the cells cannot be said to be either alive or dead, in the ordinary acceptation of these words. It is a new and hitherto unobtained condition of living matter—a third state. A final instance of the application of the above methods may be given. Certain species of bacteria, during the course of their vital processes, are capable of emitting light. If, however, the cells be broken up at the tem-

perature of liquid air, and the crushed contents brought to the ordinary temperature, the luminosity function is found to have disappeared. This points to the luminosity not being due to the action of a ferment—a "Luciferase"—but as being essentially bound up with the vital processes of the cells, and dependent for its production on the intact organization of the cell. These attempts to study by frigorific methods the physiology of the cell have already yielded valuable and encouraging results, and it is to be hoped that this line of investigation will continue to be vigorously prosecuted at the Jenner Institute.

THE RELATION OF PHYSICS TO MEDICINE.*

BY WINFIELD S. HALL.

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It may come as a surprise to some of us that there can be anything more than a remote relation between the science of physics and the practice of medicine. But we must not forget that the legitimate practice of medicine today deals with the physical body governed by physical laws, and it may be said in brief that the problems of scientific medicine are either problems of physics or of chemistry. It may be of interest here for us to recall for a moment some points in the life of one of the great physicists. Helmholtz, that world renowned expounder of your science, was a great physicist and he was also a great physiologist. Some of you may not know that Helmholtz received the degree of Doctor of Medicine from the University of Berlin about the year 1847 on a thesis entitled "The Nervous System of the In-

* In response to a toast at the banquet of the Central Association of Physics Teachers, November 28, 1902.

vertebrates." The two professors who influenced him most were Johannes Müller, the great pioneer in experimental physiology, and Magnus, the inspired teacher of experimental physics. Associated with Helmholtz as students were Du Bois Reymond, Virchow, Brücke, Claussius, Kirchhoff, Quincke, Seimens, Tyndall, and Wiedemann, who were masters in their several fields of experimental science. You remember that Helmholtz published a brief classic on the "Conservation of Energy," in 1847, and though he was not the first to formulate this theory, it was he who presented it in such a form as to bring it forcibly to the attention of the scientific world. Helmholtz's first professorship was at Königsberg where he was head of the department of anatomy, physiology and pathology. In this position his earliest work was in anatomy, on the mechanics of respiration. His attention soon, however, was turned to the physical problems of physiology, for which work he was especially well adapted by training as well as by his natural inclination. His first work was to determine *the velocity of nerve impulses.* Then followed his exhaustive work in optics. The earliest achievements being the invention of the *ophthalmoscope,* followed soon by the *ophthalmometer.* These instruments have been of inestimable value to the medical profession. He continued his activities in the field of physiologic optics until it bore fruit in that classic work: *"Physiological Optics"* ("Physiologische Optik."). He turned his attention then to the problems of physiological acoustics, resulting in his classic work on science of sound ("Tonempfindung"). This work is of inestimable importance to physiologists, psychologists, physicists, and to musicians. After twenty-two years spent as teacher of the physical problems of physiology, Helmholtz was called to the University of Berlin as Professor of Physics, which position he held until his death.

I have spoken thus extensively of the work of Helmholtz in order to show once for all the intimate relation between physics and medicine. I have said that the problems of physiology are problems of physics or of chemistry and the better preparation the student has in these two sciences before he enters upon the

study of medicine the more secure will his foundation be and the more sure his success in the practice of scientific medicine. It will be of interest to you to hear the enumeration of the chapters of physics in which the student of medicine must possess a good working knowledge.

In order to be enabled to solve problems of locomotion it is necessary that the student be thoroughly acquainted with *mechanics*. He should be able to compute the number of work units performed by a muscle in transporting the body through space under various conditions. He should be able to translate this work unit into heat units and this in turn into food units. He must be acquainted with the principles involved in the transformation of energy.

If he is to be able to solve the problems involved in circulation and respiration he must be acquainted with the principles of *hydraulics,* the laws which govern the absorption of gases by liquids and the laws which govern the diffusion of gases.

A knowledge of heat formation, condensation, diffusion, of thermometry, of vaporization, of radiation, and of calorimetry, will be requisite.

A working knowledge of *acoustics* will be necessary if he is to understand the functions of the vocal organs and the organs of hearing, and if he is to be able to treat these organs successfully in his capacity as a practitioner of medicine. No less thorough knowledge will be necessary in *optics*—a knowledge of reflection and refraction of refractive media, prisms, lenses and of optical instruments.

Electricity is used as a stimulus in the physiological laboratory. It is used for the diagnosis of various diseases of the neuromuscular apparatus and it is used in the treatment of various diseases. In order to use this most valuable agent in physiology and practical medicine intelligently, the student must be acquainted with the principles of various cells and batteries. He must have a thorough knowledge of the application of Ohm's law, and be able to compute accurately the amperage of his current, given the voltage of his cell and the resistance of the circuit and the method in which the circuit is joined up. He must be acquainted with

various electrical appliances such as the inductorium, rheostat, and galvanometer.

From this brief outline of the course in physics which every student of medicine should master before he enters upon the study of medicine there can be no doubt as to the relation between physics and medicine. It is the same relation that the foundation bears to the superstructure. The stability of the latter depends upon the stability of the former. Medical practice in the times of our grandfathers was securely ensconced behind the vail of mysticism. Modern science and research have rent this vail asunder and we approach the problems of medicine today with the same spirit and same methods that the physicists and chemists use to solve the problems of their sciences. As your science of physics grows, so will our science of medicine grow. The future has many triumphs in store. You will lead the way and we of the medical profession will follow.

WHAT OF CHEMISTRY SHALL BE TAUGHT IN THE HIGH SCHOOL AND HOW SHALL IT BE MOST EFFECTIVELY TAUGHT?

BY L. M. DENNIS,

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Most educators are agreed that instruction in at least one of the natural sciences should be included in the curriculum of high schools and preparatory academies. Among these sciences, physics and chemistry occupy positions of prominence, and instruction in one or both of these subjects is usually offered. Before speaking to the question, "What of chemistry shall be taught in the high school and how shall it be most effectively taught?" let us consider for a moment the conditions under which it is desirable to teach both physics and chemistry in the high school and which of the two sciences should be selected if only one is to be offered.

There are two distinct aims in the teaching of science in the high school. The first of these is the cultivation of the habit

of close observation and of accurate deduction from observed phenomena; the second is the imparting to the student of information intended either merely as an addition to his fund of general knowledge or as preparation for advanced work in this line in some higher institution of learning. Regarding the first point, it is, I believe, true that a scientific habit of thought may be equally well developed by properly conducted courses in either physics or chemistry, yet instruction in physics should precede that in chemistry, because an understanding of the phenomena of heat and electricity and of the laws of mechanics will be of great aid to the student of chemistry and is indeed an almost indispensable preliminary to the profitable performance of his work. If then, in arranging the course of study for the high school, it is felt that time can be found for only one of these sciences, physics should undoubtedly be given the preference.

Touching the second point, the imparting of information to the student, it will generally be conceded that if the education of the student is to terminate with the high school course, the knowledge that he will acquire in the study of physics will be of fully as great utility to him in after life as that derived from a course in chemistry. The instruction which can be given in a high school in either of these branches can not make of a student either a physicist or a chemist. Consequently it is futile to argue that a high school preparation in one or the other of these sciences will be sufficient to enable the pupil to use the knowledge thus acquired as a means of gaining a livelihood, and that consequently one who is intending to fit himself as a chemist should receive in the high school instruction in chemistry even to the exclusion of physics. No one can hope to become a properly trained chemist unless he is thoroughly grounded in the other science. As has been said by one of the greatest teachers of science of the preceding century, "a chemist who is not a physicist is nothing at all." Hence there will be no gain in time for the student of chemistry, if he be given chemistry instead of physics in the high school, for instruction in the latter subject must be received either then or at some later time in his training. It would seem, therefore, whatever the aim in view, that the curriculum of a high school should first of all provide a thorough course in physics, ac-

companied by laboratory instruction, and that chemistry should be taught only when time will permit of its following a year of training in the other science.

This brings us to the question of the "What" and "How" of the chemistry to be offered to the high school pupil. If the teacher is well fitted for the work and the facilities for class room and laboratory instruction are adequate, no branch of science will prove of greater profit and interest than chemistry, to the student properly prepared to undertake it. The preparation of the teacher should include *at the least* a year of lecture, recitation and laboratory instruction in general inorganic chemistry amounting to about six actual hours a week (or the equivalent of such a course), together with a full year devoted to qualitative and quantitative analysis. If this can be supplemented by training in elementary organic chemistry, and a brief course in physical chemistry, the effect will soon be manifest in the greater success of the teacher, a greater power to make the subject a "live" one to the pupil, and in the greater enthusiasm and clearer understanding on the part of the student.

Yet no matter how complete may have been the training of the teacher, it is hopeless to expect to obtain satisfactory results if suitable laboratory facilities are not at hand. And it is exactly in this respect that many of the high schools in our smaller cities and towns labor under serious disadvantages. A laboratory for instruction in physics can be installed in a room of usual construction and can be equipped once and for all by the purchase of a suitable stock of apparatus. A chemical laboratory, on the other hand, should be especially planned for the purpose for which it is to be used. It must have large table space, a more or less elaborate system of plumbing, adequate ventilation not merely of the "hoods" for carrying off noxious gases, but also of the entire room, and it must be equipped with a large stock of chemicals and fragile glass apparatus, which must be constantly renewed. If the money available for the teaching of science in the high school is not adequate to properly construct, equip and maintain such a laboratory, then again it will be wiser to concentrate upon physics rather than to attempt to offer chemistry under unfavorable conditions.

The course in chemistry should first of all comprise a full year of work in general inorganic chemistry, with experimental lectures, laboratory practice, and recitations. It is unfortunate that in certain schools some qualitative analysis is included in this first year of chemistry; the time is none too great for inorganic chemistry alone, and the small amount of qualitative analysis that can be given in connection with the inorganic chemistry will prove of but little benefit to the student. If anything is to be added to the inorganic chemistry in the first year, let it rather be a brief study of the commoner compounds and processes of organic chemistry.

Both in the lectures and the recitations, it is inadvisable to make early use of the symbols or formulæ or of equations to express chemical reactions. If the student begins with the study of hydrogen and prepares that gas himself in the laboratory, we should not insist that he learn at that time either the formulæ of the substances which he uses or of the products which are formed. At this early stage it is quite sufficient that he know that zinc and sulphuric acid, when brought together, will set free a gas that is termed hydrogen, and that he then ascertain the properties of this gas by actual experiment.

As preliminary to the work of the laboratory, brief instruction in the setting up of apparatus should always be given by the teacher. Students should be shown how to draw out, bend and join glass tubing, how to clean chemical glassware, and how to properly support the different pieces in position. Skill in the handling of apparatus is a most essential acquisition for a chemist, and proper training in this matter thus early in his career will save him from many vexatious delays and even failures in his later work. At the beginning of each period of laboratory practice, the teacher should explain to the class what is to be done and should set up the apparatus that is to be used. Each student should then be required to neatly and properly put together the apparatus for each experiment, following the model which has been shown to him. Careful observation and accurate statement of experimental results by the student should be culti-

vated, and he should be impressed with the importance of "experimental honesty." By that I mean that he should be encouraged in stating exactly what he has seen in the experiment and should not be given the idea that if his results do not agree with the statements in the textbook, his work will be regarded as a total failure. The experiment should, of course, be repeated until proper results are obtained, and the understanding of the reasons for the failure and for the subsequent success will then double the value of the work to the pupil. Indeed, many chemists are wont to say that more can be learned from an experiment that has "failed" than from one that has succeeded, and it is a fact that some of our most important discoveries have thus been made. Training in accuracy of manipulation, observation and statement should, therefore, be the first object of the teacher, and a carelessly performed experiment, which happens to agree in its results with the statements in the textbook, should be regarded as half a failure.

I trust that what has been said will not be regarded as in any way intended to discourage the teaching of chemistry in the high school, when the conditions are favorable. On the contrary, it is earnestly to be hoped that the instruction in this subject will be constantly extended, provided always that it is of a high standard of excellence and is offered to students properly fitted to reap its benefits.—*American Education.*

WEATHER WORK IN THE SCHOOLS.

BY H. W. HARMON.

Department of Science, Southwestern State Normal School, California, Pa.

The U. S. Weather Bureau is attempting to extend its usefulness in all practical directions. One sees in the various weather bureau reports and bulletins statements to the effect that the more completely the people at large understand the weather maps, forecasts and elements of weather, the more effective the work of the bureau will be. And if the growing generation in the schools be instructed along these lines the utility of this already very useful branch of our government will be increased many fold.

With this in mind, as well as the fact that the study of the weather is a useful, interesting and practical division of the subject of physics, there was planned for the four divisions of our class in physics (numbering about 110) a scheme of weather observing. This was regarded as a part of the laboratory work and was so arranged that each of the members of the class should have one week at least of observing sometime during the school year.

Our normal students, under training soon to become teachers in grade schools and high schools, would expect work of whatever nature to stand the test of practical use in their own schools. This was deemed possible by simplifying and reducing somewhat the extent of the observations to meet the conditions of their schools.

If this be so for the grade schools and to a much fuller extent for high school students studying physics, large numbers of these young people, soon to be a part of the world's active life, would be somewhat grounded in the principles governing weather, and able to make good use of the weather bureau forecasts, maps, bulletins, etc.

The plan of student observation was this:

Each of the four divisions of the class was represented by one of its number, thus making a group of four observers. These four students took observations from the various instruments for

one week. The following week a new group of four replaced them, and so on throughout the year.

The report on these observations was in the form of what we call the physics thesis, the general thesis subject being "Weather." In this thesis would be found the report of the weather of the whole month in which the observer's week came, also in more minute detail the weather of the observer's own week and the weather conditions carefully analyzed and related. The curves of barometer, mean temperature, dew point and wind direction changes for the month, would be drawn and by these and from the record data the rules given for forecasting weather changes were to be verified or disproved (these rules to be enclosed in the report). Other rules their observations might suggest were to be given. The instruments used were to be briefly described and method of use and principle explained. Drawings of instruments, flag signals, storm centers, weather maps, etc., were often inserted to illustrate or aid in explaining the various topics.

Especial emphasis was laid on originality and careful thought in the relating of the various weather factors; thus it could be regarded as evidence of the student's ability to handle thoroughly and well such a subject. The thesis reports were due by the 30th of the following month. The weather work was made a part of the daily recitation work. Early in the year before starting the student observations, lantern slides of the various instruments and typical weather-map storms were thrown on the screen and explained. The principles involved in the barometer, thermometer and hygrometer were assigned as lesson topics. This being finished, observation groups were started. Partial records of the weather factors were placed on the black board each day(barometer, wind direction, dew point, per cent of moisture, locality of the storm center, amount of rain, temperature and sky), and the first two or three minutes of each recitation period were spent in the discussion of weather conditions, the group members being leaders. Much interest has been taken in these brief discussions.

The instruments used are the rain gauge, maximum and minimum thermometer (these together with the instrument shelter being supplied by the Weather Bureau, this being a volunteer station), wet and dry bulb and hair hygrometer, barometer (we

use both mercury and aneroid to check each other) and wind vane. The motion of smoke gives a chance to estimate wind velocity and clouds are named by comparing with those of the U. S. Hydrographic Office Cloud Chart.

The observations are recorded in the laboratory record book and also each observer keeps his own record for his week.

The observations of instruments were made at 8:00 a. m. and 4:00 p. m. each day. The group observers, after completing the observations, compare them with those of the previous time and from the rules for forecasting and the position of the storm center shown on the latest weather map, make their predictions for the next 12 or 24 hours. They then display the proper weather signal flags from a small flag staff fastened to the instrument shelter. Keen interest is taken in the outcome of their prediction. The whole school understands their meaning and the group wish success to avoid the fun poked at the "weather man" by their classmates. However, a large part of the observers have been quite successful in their forecasts.

The following are the summarized rules used in forecasting:

WEATHER INDICATIONS.

Barometer Changes.

Rise = Fair weather or a clearing up of a storm.
Fall = Approach or increase of storm.

Humidity.

1. Slight changes of dew points—Fair weather.
2. Wide changes of D. P.—Foul weather.
3. Rising dew point—Warmer.
4. Falling dew point—Cooler.
5. Rapidly fluctuating D. P.—Windy.
6. Rapid rise of dew point to 70° F. with muggy air—Thunder storm.
7. Falling dew point to 32° with clear sky and no wind—Frost.

Winds.

1. North. Slight rain or snow (with falling barometer).
2. North-east, east or south-east. Heavy rain or snow.
3. South. Slight rain or snow.

4. South-west, west or north-west. Fair and cooler (with rising barometer).

5. Winds shifting from north-west to south-west and to south. Approach of another storm. ("When wind veers against the sun, trust it not for back it will run.")

NOTE I.—Storm center is to the left of the wind direction. Point the fingers of the right hand in the direction the wind is going and the thumb will be pointing toward the storm center. Fair weather is to the right of the wind direction.

NOTE. II.—The wind velocity is higher as the amount of barometer difference between the "Low" and "High" is greater.

Clouds.

1. Cirrus or cirro-stratus with falling barometer. Approach of bad weather or distant storm. "Mares tails and mackerel scales make lofty ships carry low sails."
2. Alto-stratus, cirro-cumulus, strato-cumulus, fracto-cumulus and nimbus with falling barometer. Rain or snow.
3. Same in reverse order with rising barometer. Fair weather.
4. Cumulus, rapidly forming with high humidity. Thunder storm.
5. Alto-cumulus at Sunset. Fair.

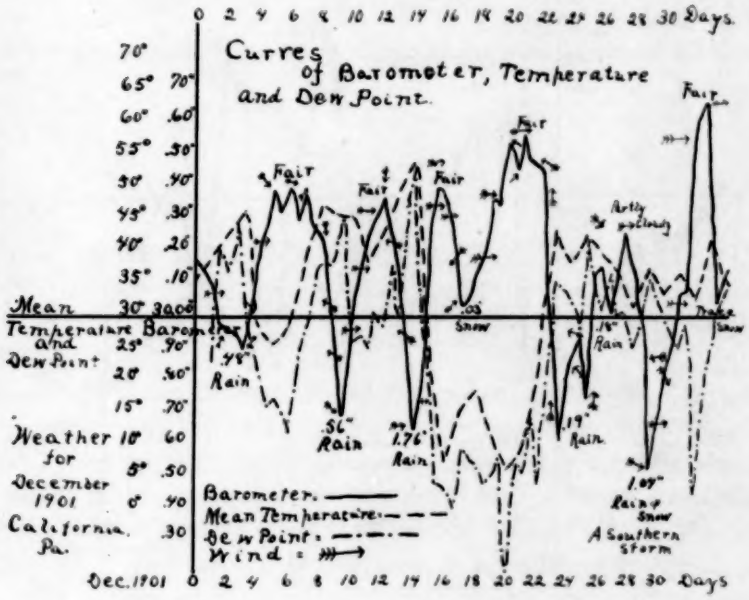
Sky.

1. Fresh blue. Fair weather.
2. Pale blue. An approaching storm.
3. A clear stretch of sunset, red close along the horizon, this surmounted by yellow, indicates fair weather for following day.
4. A LURID western sky, a sunset with colors spread above the horizon on thin cirrus clouds. Storm coming.
5. Dirty and dull with sky in east clearer. Storm nearer.
6. Rainbow, in east, "at night sailor's delight; rainbow in morning sailors take warning."
7. Halo around sun or moon. Approach of storm.

To save the students time, a printed weather record blank has been in use. The various weather factors are recorded on it and on its back is the monthly summary. The size of the blank 15″x15″, to be folded in the middle and from the bottom to fit the covers of the Science Tablet Physics Record (Central School

Supply House, Chicago). The thesis is written up on the writing sheets, illustrated on drawing sheets, and curves drawn on co-ordinate paper prepared for these covers, and thus, it is, when completed, for the student teacher, a well-bound, condensed, elementary treatise on weather for their future use. The students seem to have found the weather an especially interesting subject, and the reading through of their theses has time and again given me the above impression.

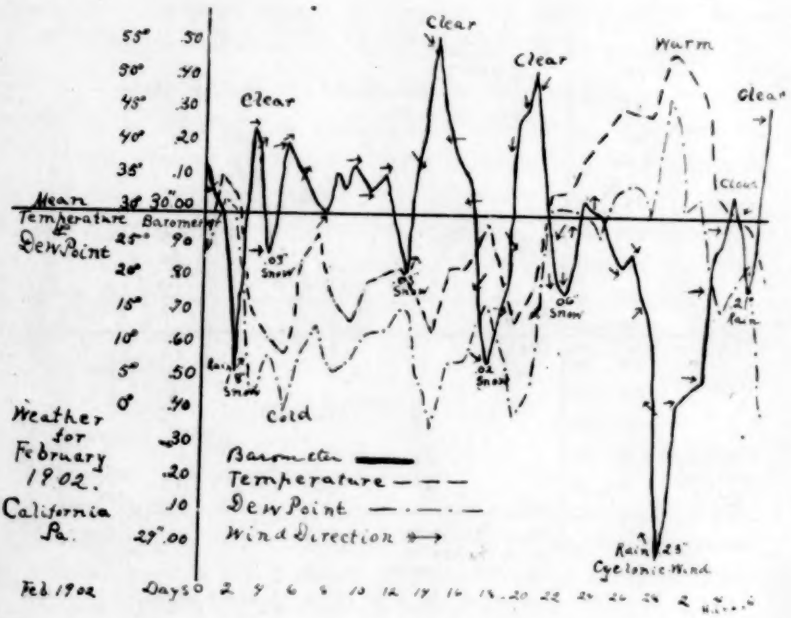
The curves showing the changes in the barometer, mean tem-



perature, dew point and wind direction, drawn on the same sheet of cross-section paper, the origin being the same for each, days of month for abcissa, and pressure and mean temperature for ordinates, show very graphically the very close relations between these four most important weather factors. The accompanying curves for the month of December and February being typical diagrams of a month's weather changes. The number of lowest barometer points with the accompanying cloudiness, rain or snow, indicates

the number of storms passing during the month, and the number of high points with the accompanying "Fair" weather, the number of "Highs" or anticyclones. A glance shows the dew point and temperature curves rising together as the barometer falls, and falling when it rises. Also the wind directions which bring the rain and the fair weather.

Being on the Monongahela river, and as it frequently varies in level from low water to flood levels, the students have been



studying the relation between rainfall and river rises. They determine the ratio between the amount of rainfall in inches to the rise of the river in feet, the soil conditions being taken into consideration, and are thus able to forecast river stages.

This, and more or less all of this work, has not a little of the element of original investigation in it, and all have become more close observers of the varying phenomena of nature around them.

The children of even the lower grades can and do take interest in the simpler weather elements, such as the wind direction, the clouds, the rain or snow, and with but a little instruction can learn to record the changes in the barometer. A teacher can, with little difficulty and but trifling expense, construct or supply, a more or less accurate wind vane, rain gauge, cheap thermometers, a hygrometer; also with glass tubing and a little mercury could make a fairly accurate siphon barometer and thus have instruments for taking all of the most important weather factors.

Weather work, therefore, seems to have in it elements of interest, educational value and practical utility for children in the lower grades and in grades up to that of the most advanced students.

THE DETERMINATION OF THE WEIGHT OF A LITER OF AIR.

BY C. E. LINEBARGER.

In Volume I, page 28, of this journal, is given a method of determining the weight of a given volume of air.* While the method is excellent for demonstration purposes it is hardly simple enough to put in the hands of pupils. The following simplifications, however, make it well adapted to student's use. The apparatus is such as can be obtained in abundance at almost no outlay of money.

The top of a "tomato can" is melted off and the melted off bottom of another can soldered on in its place. A hole about 3 mm. in diameter is pierced in the can thus prepared and a bicycle valve soldered over the hole. It is very necessary that the valve be air-tight even when its cap is not screwed on.

The valve is connected with a bicycle pump and air pumped into it. The sides of the can will bulge out somewhat, but if

* A Convenient Method of Determining the Density of Air, by A. W. Augur.

the soldering has been done with care, the pressure may be brought up to about three atmospheres without any danger of the can springing a leak. It is perfectly safe to pump in as much air as possible as the can will always spring a leak at its weakest point and will not explode as a glass vessel would.

The can thus filled with compressed air is weighed to centigrams. It is then connected by a piece of ordinary rubber tubing with a large aspirating bottle, a match with its head broken off being placed beforehand in the tubing just over the valve. Precautions having been taken to have the pressure of the air in the aspirator equal to that of the atmosphere, the rubber tubing is pinched just over the valve and the match stick thus grasped, is pushed down so as to open the valve a little. This is repeated until no more air escapes from the can.

As the air in escaping from the can is cooled by the expansion it is necessary to wait several minutes before disconnecting so that the air may be warmed to the temperature of the room again. The valve should be kept open for a minute or so when the overflow vessel is so arranged that the level of the water in it is the same as that of the water left in the aspirator.

The can is now disconnected and weighed. The volume of the water which has been driven out of the aspirating bottle is measured and reduced to standard conditions.

The method recommends itself not only for its simplicity and excellence of results but also for the cheapness of the materials. A teacher has only to ask his pupils to bring in cans and bicycle valves to obtain for nothing a plentiful supply, and the labor of preparing the cans is but slight. When once a stock is on hand it is ready for use at a moment's notice.

A METHOD OF DETERMINING THE VALUE OF GRAVITY.

BY F. H. FOSTER,

Instructor in Physics and Chemistry, Princeton (Ill.) High School.

A problem, which I have almost invariably found to be of interest to my pupils, is that of finding the local value of the earth's gravity. Unfortunately, the method of determining this constant by means of the ordinary pendulum gives such poor results that it is usually valueless. Several years ago I devised a simplified form of Kater's pendulum, which has proved so satisfactory that I offer it with the hope that others may find it useful.

The apparatus consists of a brass rod, about 150 cm. long, with a diameter of one centimeter. The rod may be suspended from one end by a steel knife-edge, *a*. Another knife-edge, *a'*, facing the former, is attached to a brass ellipsoid, sliding on the rod, and provided with a setscrew, *b*. At each end of the pendulum is soldered a platinum wire, making contact with a drop of mercury in electrical connection with a telegraph sounder. The apparatus may be suspended from steel bearings, adjusted on either side of a slot cut in a wooden shell. It is convenient to have two sets of bearings and two slots of varying width.

The rod is first suspended from *a* and an approximate value of this vibration-period obtained. It is then suspended from *a'*, and the slide adusted until the time is about the same as from *a*. In practice it is well at this point to have the student determine clearly the effect on the time of both sets of vibrations of successive small movements of the slide. Finally, by carefully adjusting the movable knife-edge, the time of one or two thousand vibrations will be the same, taken from either point of suspension. An accurate measurement of the distance between the two knife-edges will now

give the length of the simple pendulum having the obtained vibration rate. A good stop-watch is needed; or, by lightly touching and releasing the balance wheel, estimating to fifths of a second, an ordinary watch may be successfully used. My students have obtained results differing from the computed value by about .03 of one per cent.

THE VOLUMETRIC SYNTHESIS OF WATER AS A PRACTICAL QUANTITATIVE LECTURE EXPERIMENT.

BY ERNEST F. BURCHARD,

Instructor of Chemistry, Sioux City (Ia.) High School.

In order to illustrate this phase of the Law of Gas-volumetric proportions to a nicety, and that the experiment may at the same time become a working exercise for the class in the application of the Law of Charles, the essential piece of apparatus is a special eudiometer, *E*, (Fig. 1) at least 50 cm. in length, with a stopcock at the top, and is graduated to 1/10 cc. from the stopcock downwards. Its total capacity should be about 60 cc., and the lower end should be ungraduated and tapered slightly with a swell or ring at the terminus for secure fastening of a rubber tube. The platinum wires pass in at the shoulder, just below the stopcock.

This eudiometer is enclosed by a steam jacket, *J*, a tube of good, clear glass, 45 cm. long, 5 cm. inside diameter, and 3mm. wall. A stout triple-bored rubber stopper fits the bottom, and through it pass the eudiometer and two small tubes, one for the admission of steam, the other to drain off water. To the lower end of *E* is securely fitted at least 75 cm. of fresh, clean (preferably antimony) rubber tubing of 6 mm. inside diameter and 3 mm. wall, to the other end of which is cemented a 6 cm. glass funnel. The whole is supported in an upright position, and

a convenient rest for the funnel is made by sawing a small section out of a small iron ring, in order to slip the funnel easily in and out.

When the apparatus is ready it must be thoroughly dried by a continued blast of hot, dry air, after which the stopcock is closed, the funnel corked, and the whole allowed to cool, after which the eudiometer may be completely filled with mercury that is known to be clean and dry. (It is best to subject the mercury

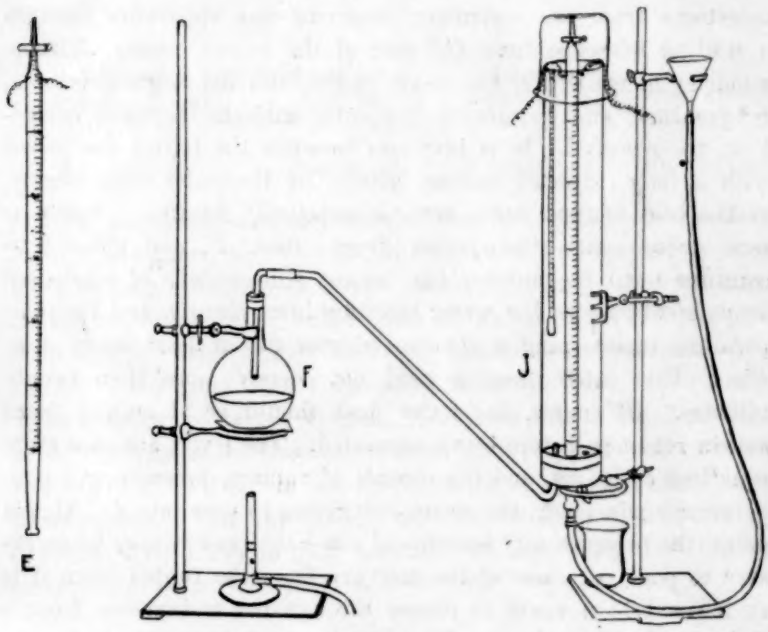


Fig. 1.

to a thorough cleaning, warming and drying in a dessiccator before using it.) The mercury should about half fill the funnel. The electrolytic gas is generated in the usual way, by electrolysis of pure water acidulated with H_2SO_4, and dried by passing through calcium chloride and concentrated sulphuric acid, from which wash bottle it is passed into the eudiometer after having continued in action for a safe interval. It is essential that the electrolysis apparatus and wash bottles be stoppered absolutely

tight. It may be most convenient to place the gas delivering apparatus on a box in order to bring it near the level of the top of *E*. The gas is admitted to the top of the eudiometer, the tube above the stopcock having been filled to the brim with mercury. While the gas is passing in, the funnel is slowly lowered, until about 10 cc. of the gas is in the eudiometer at atmospheric pressure.

The levels of the mercury in the funnel and within the tube may be most accurately adjusted by a student, who receives his directions from the instructor observing the apparatus through a reading telescope from the rear of the lecture room. A thermometer hangs within the steam jacket, and the original volume, temperature, and barometric pressure, with temperature correction, are recorded. It is best now to cover the top of the jacket with a long, inverted beaker, which fits the outer tube closely, as the heat is thus much more satisfactorily retained. Steam is now passed into the jacket from flask, *F*, and allowed to continue until the interior has become almost clear of condensed drops of water, the hot water running down cleanly, and the temperature maintaining a constant degree for at least seven minutes. This entire heating need not occupy more than twenty minutes. Of course, the water flask should be at boiling point and in readiness before being connected. The levels are once more equalized as before, and the records of volume, pressure and temperature again made, the steam continuing to pass into *J*. At this point, the pressure may be reduced one-half (and it may be necessary to pour out some of the mercury from the funnel when it is so lowered). A spark is passed through the eudiometer from a Ruhmkorff coil or from a Wimshurst machine, and the gases exploded. The levels are now readjusted, and the volume, temperature and pressure recorded. The steam may then be discontinued, and the apparatus allowed to cool until the steam within the eudiometer has condensed, and the effect on its volume observed and noted.

If the electrolytic mixture of hydrogen and oxygen has been pure and dry, and the mercury and interior of the eudiometer have been clean, dry, and all air has been excluded, very accurate results may be expected from the experiment, and the residual

gas, after exploding and cooling, will be inappreciable. Considerable time is, of course, necessary in preparation for this work, and a preliminary trial is advisable, but the actual operation may be successfully carried out in one recitation period, with the exception of allowing the apparatus to cool fully to the temperature of the room, provided everything is in readiness.

The special eudiometer may also be used to demonstrate the Laws of Boyle and Charles, separately or combined.

The following data were obtained in a class-room experiment as outlined above:

I	II	III	IV
Original	Same after	After	
Hydrogen + Oxygen	heating	exploding	After cooling
V = 9.88 cc.	V = 12.5 cc.	V = 8.3 cc.	V = 0.15 cc.
T = 21°.5	T = 98°.7	T = 98°.7	T = 25°.0
P = 727 mm.	P = 727 mm.	P = 727 mm.	P = 727 mm.

In the pupil's report, besides the description of the usual details, drawings, and records, answers may be expected to some such leading questions as these: What volume would 9.88 cc. of a mixture of hydrogen and oxygen at 21.°5, and 727 mm. pressure occupy when heated to 98.°7, the pressure remaining the same? How does this correspond with the observed volume? What percentage of the original volume of gas at 98.°7 remains after the explosion, the temperature and pressure both remaining constant? What is the resulting gas? What becomes of it when cooled? Has any matter been lost or destroyed during the experiment? How do you account for the change? Has the proposition (what was it?) been proved?

Metrology.*

SYSTEM IN METRIC WEIGHTS AND MEASURES.

(*Concluded from page 413.*)

A practical illustration of the importance attached to correspondence between different kinds of measures is found in the measure used by mariners of one second of arc on the earth's surface. Why should this be called a (nautical) *mile*? Simply because the real mile used for measurement on land is but a little shorter. It really causes confusion between the measurement established on land and at sea, and sometimes serious mistakes.

But the people of the United States have thought that it was convenient to have the minutes of an arc called a mile, even in spite of its lack of exactness. Their Public Land System, by the way, lays out townships by meridians and parallels run astronomically.

Even if the different systems above outlined had been more complete, their use in combination with one another would have been inconvenient from their conflicting. What is wanted is to have the same arithmetical progression in large as well as small denominations of any one kind of measure, in multiples as well as in subdivision; also to have the same arithmetical system in all kinds of measure; also to have the units of measure of different kinds related to one another. It is this completeness of system which makes the metric weights and measures so very much more convenient than the grotesque confusion of fragments of various systems long customary in the United States. The metric system affords a much better mental grasp of magnitudes and their relations to one another, and is much easier to learn and remember. This has been tersely stated in some leading articles of *Engineering* (London) from which the following sentences are quoted:

"No one can be so dense as not to be able to understand its main features in two minutes. In the decimetre—any other name would do as well or better—we have a convenient standard of

* Communications for the Department of Metrology should be sent to Rufus P Williams, North Cambridge, Mass.

length. A cube of this dimension furnishes the unit of capacity, the litre, while the weight of a litre of water is the unit of weight, the kilogramme. That is the whole of the metric system, and it passes the wit of man to devise one simpler or more convenient." (Vol. 67, p. 519, April 21, 1899).

"Its grand features are that it is based on a single unit both for measures of length, measures of weight, and measures of quantity, and that it admits only one divisor. The gain implied in these two propositions is so immense as to completely overshadow all the criticism that can be brought to bear on its less satisfactory features." (Vol. 61, pp. 509-10, April 17, 1896.)

The convenience resulting from this systematic quality in the practical application of the metric units to various kinds of work was pointed out in an excellent paper on the Metric System of Weights and Measures, read by A. Hanssen before the Civil and Mechanical Engineers' Society and printed in *Engineering* (London), v. 67, pp. 295-6 (March 3, 1899); from it a few quotations may be made:

"Take, for instance, a substance like cast iron, the weight of which we constantly have to calculate from the volumes shown on drawings or described in specifications. Its average specific gravity is 7.23, that is to say, it weighs 7.23 times more than an equal volume of distilled water. This single figure tells us at once that a cubic centimetre weighs 7.23 grammes, a cubic decimetre weighs 7.23 kilogrammes, and a cubic metre weighs 7.23 tonnes. A plate 1 square metre in area and 1 millimetre thick has a volume of 1 cubic decimetre, and it is therefore easily remembered that sheets of cast iron weigh 7.23 kilogrammes per square metre for each millimetre in thickness. If we have a given weight of cast iron, and want to know what volume it occupies, we only have to divide the weight by this one magic factor of 7.23. To convert the grammes and kilogrammes into tonnes it is necessary to insert the usual comma for every three figures of the result."

"With the metric system the quantity of water to be lifted is given in litres or cubic decimetres per second, the speed of the piston is given in decimetres per second, and a division of the first figure by the second gives the area of the pump in square decimetres. The diameter is found from this in decimetres, and we have only to move the decimal point to make them into millimetres."

"This reduction of work by using the metric system, holds good for most calculations made by engineers and architects. The

amount of unnecessary work done by quantity surveyors for the building trades, when taking out quantities, is immense. On the Continent all dimensions are in metres, and one or two multiplications give at once all quantities in squares or cubic metres."

"In the metric system the mean pressure of the atmosphere at sea-level is almost exactly equal to 760 millimetres of mercury, which is equal to a column of water 10.333 metres high or to 1.0333 kilogrammes per square centimetre. Slight pressures, such as the pressure of coal gas, or the vacuum in a chimney stack, are expressed in millimetres of water, of which 10,333 are equal to an atmosphere, or by kilogrammes per square metre, of which, again, there are 10,333 to an atmosphere. These measures are readily interchangeable without any calculation, and depend upon the fact that a tube 10 metres high, with a sectional area of 1 centimetre, will contain exactly 1 litre of water, which will weigh 1 kilogramme, and the pressure exerted by the water in the tube against its base is, therefore, equal to 1 kilogramme per square centimetre for each 10 metres iiin height."

One way in which the superior simplicity of relations among metric units is manifested is in the assertions put forward by opponents who argue that old weights and measures are used conveniently by the application of ingenious approximations toward relationship which for various classes of calculation have been devised and are remembered by the special workers in those classes of work. One very eminent man who has emphasized this would-be adverse argument was Sir Frederick J. Bramwell, formerly president of the Institution of Civil Engineers of Great Britain. He presented his idea embodied in which he called "Short Cuts," before the special committee of the House of Commons which heard a great deal of evidence in 1895.

Sir Benjamin Baker, who has also been president of the Institution of Civil Engineers, was examined immediately afterwards, and some extracts from his testimony follow:

"I know hundreds of English engineers who have drifted necessarily into the metric system and the decimal system, and I have never heard one who would come back to the English weights and measures ii they had the option. In numberless cases it is so much easier. You have only got to remember the specific gravity of different substances and you get all you want readily without short cuts, whether it is iron, or brick, or other material." (From answer No. 2625.)

"I quite agree with the honorable chairman that those short

cuts are rather an evidence of the inconvenience of the present system; if it is worth taking the trouble to get those coincindences and to search for them. And none of Sir Frederick Bramwell's were quite right, although they are nearly." (From answer No. 2647.)

"2648. And you do not want a short cut when you have a straight road? ——— No."

Those so-called "short cuts" are like other approximations that may be found between metric values and different physical constants. The pressure of the atmosphere, stated above to be 1.0333 kilos on a square centimeter, is obviously very near to 1 kilo per square centimeter and in mental calculation may often be taken with sufficient accuracy at that round figure. The length of the second's pendulum is just about one meter, and the acceleration of gravity per second is just about 10 meters, both values varying slightly with latitude and elevation. The townships of the United States public land system are nearly a square myriameter. A common brick is about ten centimeters wide by twenty long. A gram of gold coin is worth 60 cents. That these statements are easier to remember than figures precisely correct is a fact which is not worth very long talking about.

NOTE.

The Textile Industries.—To secure an expression of opinion from the textile industries upon the introduction of the metric system of weights and measures into the United States as proposed by bill H. R. 2,054, reported favorably last winter to the House of Representatives, the editor of the *Textile World* addressed the following questions to a number of the prominent manufacturers throughout the country:

First, Do you favor the immediate adoption of the measure?

Second, Do you oppose it?

Third, Do you favor delaying action until the subject has been calmly and scientifically investigated as in 1817 and in 1866?

Out of 47 replies, which represent the cotton and woolen industries in every section of the United States, 18 favored the metric system, 17 opposed it; 16 did not care for renewal of investigation, while 15 did; others were undecided. Several firms declared themselves as emphatically in favor of the immediate adoption of the system.

R. P. W.

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of interest and value.

BOTANY.

Nuclei in Spirogyra can be very much better seen in specimens kept in a well shaded place. In about a week they become very distinct in species, in which the cells contain two or more chloroplasts.

Hope College. S. O. MAST.

"*A vast botanical garden* is one of Dr. Engler's latest conceptions," says Dr. H. C. Cowles, in the October "Botanical Gazette." Such a garden is to display characteristic plant formations of the world; and for the sake of illustration, North America (north of Mexico) is divided into four main floristic divisions, recognizing that the great cleavage lines in the United States run north and south. This is of interest, because students in the last ten years have endeavored to make these lines run east and west. In general, the outlines are true, and, though given to indicate plans for a garden in Europe, the paper is an important contribution to American Phytogeography.

Detroit Central High School. BERNICE L. HAUG.

The production of tuberous or leafy shoots in Marjolin, a French variety of potato tuber, seems to be a matter of temperature and moisture, according to an abstract in the September *Botanical Gazette*, the tuberous shoots being due to low temperature and dryness and the leafy shoots to the opposite conditions. Leafy shoots started at high temperature, changed from negative to positively geotropic conditions, when subjected to lower temperature. The morphology and position of the tuberous shoot, then, seems to be due to temperature and moisture conditions. Miss Newell in her "Outlines of Lessons in Botany," I, p. 51, gives a similar experiment in the common potato, without assigning causes.

That the sensitive plant is a weed in any country is just as interesting to many as to learn that many of our weeds were once cultivated plants introduced from Europe. In the September number of the *Botanical Gazette*, Dr. David Fairchild of Washington gives a photograph of a field in Columbia showing *Mimosa pudica* in profusion. He says of it, "The cattle in the field had eaten the herbage close around the plant, leaving it strictly alone, and as it crept across the meadow it killed out all other plants." * * * One would think that the plant under these circumstances would be less sensitive, but the writer tells that the plants within the radius of the ground shaken by footfall went into the characteristic position of rest, and where the embankments of the railway were covered with *Mimosa*, the quick falling of the leaves with the advance of the train furnished an interesting and amusing sight.

L. M.

Reports of Meetings.

THE NEW YORK ASSOCIATION OF BIOLOGY TEACHERS.

The second meeting of the academic year was held in the biological laboratory of the Boys' High School, Brooklyn, at 9 p. m., Friday, December 12, 1902. In spite of the very inclement night, nearly thirty members of the association were present, including several from Manhattan and the Bronx.

The speaker of the evening was Dr. Gunnison, principal of the Erasmus Hall High School, who addressed the meeting on "The Relation of the Sciences to the Humanities in the High School Course." He said, in part, that in his belief the nature study side of the work should be emphasized; that fewer instruments and laboratory implements should be used, and that the work should be less scientific. The age factor is an important one and is far from being solved. The one great auxiliary use of biology was in connection with writing and English.

The speaker was followed by a number of others, all teachers of of biology, who differed decidedly with some of the points Dr. Gunnison made. In the informal discussion that followed, many points of value were brought out for the supporters of both views.

Not the least enjoyable part of the evening was the social meeting after the business meeting, at which refreshments were served by a local caterer. A series of microscopic slides, prepared and demonstrated by Mr. Lewis, of the Boys' High School, served to show what could be done with the microscope in the case of older students. A number of well prepared demonstration specimens was also exhibited, the work of the teaching corps of the Boys' High School. The informal meeting adjourned about 11 p. m., to meet January 30th, 1903.

G. W. Hunter, Jr., Secretary.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

The fifteenth meeting was held on November 15, 1902. The morning was devoted to excursions, and in the afternoon the members met in the new Dorchester (Mass.) High School building for business and to listen to an address.

At the business meeting, Miss Elizabeth Clark, of Monson (Mass.) Academy, was elected an associate member, and Professor A. A. Noyes, of the Massachusetts Institute of Technology, was elected an honorary member. The following officers were elected for the ensuing year:

L. G. Smith, Roxbury High School, president.

A. S. Perkins, Dorchester High School, vice-president.

G. A. Cowen, W. Roxbury High School, secretary.

E. F. Holden, Charlestown High School, treasurer.

G. W. Earle, Somerville English High School; Miss L. P Patten,

Medford High School; O. P. Watts, Waltham High School, additional members of executive committee.

About thirty members visited the New England Gas & Coke Company and the United States Steel Company at Everett, Mass. They were courteously conducted through each plant by officials. The following is a resumé of the visit:

The plant of the New England Gas & Coke Company was built in 1898. It has 400 Otto-Hoffmann ovens that will carbonize 1,650 long tons of coal per 24 hours. This amount of coal produces 1,400 tons of coke and 16,500,000 cubic feet of gas, about 7,000,000 cubic feet of which is for the market. The remainder of the gas heats the ovens. The yield per day of tar is 5 per cent, 82 tons by weight; of ammonium sulphate, about 1 per cent, 16 tons.

The coal is taken from the docks and carried to the bins by cable cars. The bins, holding two days' supply, are between two sections of the ovens. The coal is carried from the bins by a larry, which runs on a track over the ovens, and consists of a narrow bin with eight spouts in the bottom, through which the coal is emptied into the retorts.

The oven or retort is an air-tight chamber, 43.5 feet long, 17 inches wide and 6.5 feet high. The temperature of the oven is about 4,100° C. This temperature is obtained by burning part of the gas made at the plant. The gas does not unite with cold air, but with air that has been heated to 1,000° C. in what is called a regenerator. There are two regenerators for each set of retorts. They are used alternately, being changed every half hour. The time necessary to carbonize a charge is 24 hours.

There are two gas mains, one for carrying the rich gas which comes off first, the other for the poor gas used in the plant for heating. A ton of coal will produce 9,000 cubic feet of gas; 4,000 cubic feet are sent to the city, 5,000 cubic feet are used to heat the ovens.

When the carbonizing is complete, both mains are closed and the glowing coke is pushed out upon a platform by a ram, quenched with water and allowed to cool.

Both the rich and poor gas pass through an air cooler and several multitubular water coolers, then through exhausters and ammonia washers. Here the good and the bad part company; the good goes to the purifying plant, the bad, after being freed of its benzol, to the tank that supplies the furnace. The benzol is used later to increase the candle power of the rich gas.

At the purifying plant there are eight lime purifiers, seven of which are in use at one time, and four ferric oxide purifiers, of which three are used at one time; 7.5 pounds of lime are used per 1,000 cubic feet of gas. The ferric oxide purifiers are revivified about five times a month.

The gas furnished is from 18 to 20 candle power.

Of the 1,400 tons of coke made each day, 700 tons are sold for locomotive fuel, 350 tons to steam plants, 350 tons for domestic fuel.

The tar upon distillation gives light oils to 200° C., aniline benzol, solvent naphtha, creosote oil, crude naphthalene, anthracene oil, pure anthracene and pitch.

A ton of coal furnishes about 8 pounds of ammonia. As said before, this is converted into ammonium sulphate before it is put upon the market.

The United States Steel Company is making a high-grade steel from cheap, raw material. Old boiler plates, broken crank shafts, scrap steel of any kind, are broken up and melted for smaller castings in fire-clay crucibles; for the larger in a Siemens' open hearth furnace.

The process in brief is as follows: 100 pounds of scrap steel are melted and raised to its boiling point, 2,200°C, and from 1.5 to 2.5 pounds of ferro-silicon, containing 12 per cent of silicon, are then introduced. When this is melted, from 2 to 8 ounces of ferro-manganese, containing 80 per cent of manganese, are added. When these ingredients are thoroughly combined, the steel is ready for pouring. The figures given show the proportions only. The capacity of the furnace is 25 tons.

The steel is excellent in strength and temper, no forging, tempering or annealing being necessary. Cold chisels and hatchets can be cast and finished to shape.

Great care is taken in making the moulds. The sand used comes from New Jersey, and the clay from Martha's Vineyard. The moulds are baked before being filled with molten steel.

Gas fuel is used in the furnaces, and the gas, which must be free from sulphur, is made on the premises.

Large castings are made here, such as rams for battleships. During the visit the members saw the completion of the large mould of part of a disappearing gun carriage.

All the operations except the pouring were seen by the members.

The address of Professor A. A. Noyes was on "The Interpretation of the Uusual Scheme of Qualitative Analysis by the Help of the Ionic Theory and the Mass Action Law." The speaker discussed the main features of the ionic theory and the law of mass action, illustrated them by experiments, and applied the chief principles to the qualitative groups. The address was clear, accurate, interesting and helpful.

Mr. Charles R. Allen, chairman of the committee on laboratory construction, made an informal report on the progress of the work. From replies to a series of questions, the following is a consensus of opinion regarding the construction of a laboratory:

The total cost of material consumed per pupil is about $1.50, the divisions could not exceed 18, and the majority were of the opinion that, where there was but one course in each subject, physics should precede chemistry, though a better arrangement was suggested in the order, elementary physics, chemistry, advanced physics.

Desks should be arranged in blocks, back to back, taking from four to twelve students, with the light coming from the end, with aisles at least five feet wide between. The floor should be so constructed that it can be sluiced down, and cement or asphalt, tile, wood and linoleum were recommended in the order given. The ventilation should be something more than the gravity system, and there should be some special form of extra draugnt for the laboratory, even when power ventilation is used, this to be under the control of the teacher. An electric fan has been very generally suggested.

The laboratory should contain hoods in blocks at the sides, in the proportion of about one to four students. These should be provided with an extra exhaust, under control, as much glass as possible, with a sash front, with catch (not weights), a vitreous floor, all provided with gas, and some with a sink, and any other accessories that are provided at the desks. The flues should be of terra cotta or of copper, not iron.

Side reagents; the more common ones on shelves at points easily accessible to groups of not over ten, the less common ones in one or more cabinets along the side of the wall, these cabinets to have glass fronts and locks.

Distilled water is needed. A still is sufficient, though, if steam is

available *all the time*, that can be directly condensed. In either case, it should be kept in a tank with a spring tap, accessible to all.

The gas supply should be on an independent main from the place where the street service enters the building, with a cut-off at the laboratory, or better in the office; at all events, where only the teacher has access to it. Piping should be so large that full pressure will be maintained when all burners are going at once. There should be two cocks per student, with some extras, and the corrugated form of pillar cock should be used. Naphtha gas and acetylene may be used as substitutes, and there are some forms of oil burners that will do good work.

The provision for artificial light should consist of one good light, preferably electric, over each desk, and it should be possible to adjust the height at will.

Some sort of scales are required; for ordinary work those sensitive to 0.01 grm. are sufficient (horn pan, surgeon's army balance), while at least one accurate set should be provided (to 0.001 grm.). Where delicate balances are used, some form of weighing room is a necessity.

Evaporation can be carried on mainly at the desks with no special appliances. Asbestos mats and iron plates are convenient aids. At other points in the laboratory, steam or water baths are generally recommended, but no special evaporating devices are recommended for the hoods.

No special instructor's desk is needed in a laboratory if there be a lecture room; if not, it should be equipped as the other desks.

The water supply should be on an independent main with cut-off, as in case of gas. It should be large enough to maintain full pressure when all the taps are running. If this is not possible, the service pipe should feed into a pipe in the attic, which should give the laboratory supply.

The laboratory should be situated where no odor can annoy the rest of the school. When this can be done, it should be where the greatest number of pupils can get to it most easily. With ordinary ventilating systems, experience indicates that it is safest to place the chemical laboratory either in a wing or on the top floor.

Under all circumstances it should be adjacent to the lecture room, near the physical laboratory, and the teacher should have a private room, large enough to work in, adjacent to the laboratory, which can also be used in case of accident. A small reference library should be kept in the laboratory or office, and if this is done, the location of the general school library is immaterial.

The scientific plant should include a dark room, but it need not be directly adjacent to the chemical laboratory.

The desks should be provided with gas and water; electric taps, either at the desks or at side tables, are frequently recommended; hydric sulphide should be delivered in the hoods only, and nothing else is needed. Compressed air and vacuum are not generally objected to, but it is doubtful how far the additional complexity of the plant warrants their existence in a secondary school.

No satisfactory data could be obtained as to the area of the desks; about six square feet per student seems to be the general idea; the tops of the desks should not be of wood (tile, soapstone, opalite, glass and slate were recommended in order); water supply, with a spring cock and goose neck, with a pillar cock for attaching rubber tubing. The desks should contain sinks in the ratio of one to two students, and these sinks should be of vitreous material, with rounded corners.

The shelving should be a little wider than the bottles used, either of glass with enameled steel supports, or of wood, covered with plate glass. Wood alone is generally condemned.

The drainage should be so that a straight rod can be pushed to all

parts of it, as much of it vitreous as possible, with a collecting tank between it and sewer trap. As second choice, iron is frequently recommended rather than lead; the latter, if used, should be extra heavy.

Desks should be provided with locks, either combination or master key; any number of students may use one desk in rotation, but each should have entire use of two drawers and a cupboard. The cupboard should have shelves for reagents and hooks on the sides.

In small schools the material may be distributed by the teacher, but with large classes some form of assistance is needed, and some kind of stock room adjacent to the laboratory. A method of giving apparatus under such conditions that the student can be held responsible for its care is recommended.

Reported by LYMAN C. NEWELL.

THE CENTRAL ASSOCIATION OF PHYSICS TEACHERS.

The first regular meeting of the association was held at the Lewis Institute, Chicago, Ill., November 28, 1902, about 200 members and friends being in attendance.

The president, Mr. Charles H. Smith, of the Hyde Park (Chicago) High School, called the meeting to order at 10:30 a. m., and made the following remarks:

It is very pleasing, yes, gratifying, to be able to welcome so many who are directly interested in physics to this conference, which is virtually the first meeting of the Central Association of Physics Teachers. Your presence here is a practical guarantee of the success of this movement. Perhaps it is not out of place at this time to disclose why this conference has been called and what ends are expected to be accomplished. A little history may enable us to better understand it. For a number of years it has been the belief of many physics teachers that great good might be brought about and better results obtained by our pupils and those interested in the subject, if the instructors could come together once or twice a year to exchange ideas and discuss live and practical questions bearing directly upon our work. Last spring, after considering the responses to several hundred letters sent to the physics instructors in all of the cities and larger towns of the northern central portions of our country, it was decided to call a meeting (in June of this year) of those who replied to this initial letter, to discuss plans for an association, if it were deemed feasible. At this meeting, all attending were heartily in favor of such an organization. The result was the adoption of a constitution, in accordance to which we are assembled here today as the Central Association of Physics Teachers.

It may not be out of place for me, at the beginning of this conference, to make some suggestions as to the nature of the work, which we, as an association, can, with much profit, undertake and accomplish. Many ideas have come to me, which I will not attempt to present in any order of sequence. Possibly some of them may be work for an ideal rather than

a practical association. Yet the more ideal we become in devising ways, means and methods to help each other and assist in presenting the subject of physics to our pupils, the more nearly practical will the association become.

First in order of the suggestions is that, if this organization is to have any influence and worth, it must be of such a character and standing that it will be necessary for every person teaching physics, whether in a secondary school or college, to become a member in order to maintain any professional standing among his co-laborers. Indeed, the association must be made so strong that no physics teacher of worth can afford not to be a member and helper in it.

In physics there has never been any central body of recognized standing to which boards of education or committees, empowered with authority to make out a school curriculum, could go for information as to the proper branches of physics to be taught and how much time ought to be devoted to the study of each head. Individuals here and there have given this advice, which, while good, has had a result of no uniformity of method in presenting the subject in different schools. This condition ought not to exist; it can be remedied.

This association should assume the responsibility of writing and publishing a thoroughly up-to-date text and manual in physics which will be correlated with algebra, geometry and chemistry in such a manner that the subjects mentioned may be studied with reference to their interdependence upon each other in the class room as well as laboratory. The books, too, should contain nothing but that which is true and capable of being verified by any teacher. They should be composed of the best ideas from all good texts, together with new ideas on the subject not yet published. No hobby of some author or any fancy or showy experiment should enter. The subject matter should be correlated and presented in that manner which will make it possible for all schools where physics is taught to be teaching it in the same order after common methods. We should try to so arrange the matter of physics and the mathematics upon which it depends that the pupil will get the greatest possible knowledge of the subject in the least possible time. We might also use our influence for the better equipment of laboratories, especially in the country towns.

The public should be made to feel more thoroughly the dignity and importance of physics as it appertains to the daily affairs of commercial, social and educational life. Just how this can be brought about, I will not now stop to discuss. In this age the knowledge of physics is almost as essential to a successful career as an understanding of arithmetic. Why does arithmetic receive so much attention in the grades to the exclusion of physics? I am not opposed to the idea that the young grader ought to study his mathematics after a laboratory method along with elementary physics. We must labor for more complete sympathy for science from the grades to the secondary school and on to the college and university.

The secondary school, instead of devoting so much time in instructing a pupil in the exercises required for entrance to college, should be spending the greater part of the time in teaching the pupil physics for common daily life. The association ought to use its influence in consummating this plan. For the boy who does not go to college needs his physics far more than his more fortunate brother.

Another important point for consideration is how to bring the physics teacher and apparatus dealer, whose interests are common, into a better acquaintanceship, and this association should become a bureau of information for teacher and dealer, and should always have the names of the firm from which to purchase the best apparatus and supplies for the least money. Also, her influence should be felt among those apparatus dealers who do not yet understand that the day is past when they can dispose of old-fashioned and cheap grades of apparatus to any school. Instructors, through this organization, should inform the dealer what apparatus he can sell instead of the dealer directing what variety and quality must be purchased. The user ought to be the inventor or designer of new apparatus and the instrument maker the improver of it.

This new-born society should be an investigator of what there is to be taught and what the best method is of presenting it. This can be brought about by general discussion of live topics, as will be done this afternoon, and also by the assistance of each individual teacher, who, when he originates a new scheme, will arrange it for publication, then send it to the secretary, who will have it published and distributed in pamphlet form or else in our official organ, which we must have, and will have if the ideas of the founders of the association are carried out. If anything is said or done in the meetings of this body which is of worth, there must be a method by which all who are anxious to profit by these conferences can do so. Perhaps the editor of SCHOOL SCIENCE can be prevailed upon to make that organ the one through which we can spread the proceedings and investigations of this association to the physics world.

This subject of an official organ presents the idea of a paid secretary. If the organization is what it can be made to be, eventually a paid secretary we must have, to attend to clerical and publishing interests. His duties may be augmented by keeping a list of people who desire positions as physics teachers, and also discovering where vacancies are or are likely to occur. There is no reason why good teachers should not be helped by a body of this kind in this manner as well as in the methods of teaching.

The association, too, must act as a distributor of physics literature, whether it be its own or that written by others. It must strive to stimulate and keep in active working condition all teachers whom it can reach. It must elevate the standard of physics teaching, which must stand on as high a plane as that of any other study. We must compel the brother who is inclined to go to sleep to keep working or else drop out, from the fact that he cannot reach the high standard to be set by this organization.

It would be an excellent thing for the association to determine the

best methods for performing the best and broadest experiments (that is, those experiments out of which the pupil is to get the greatest good). A list of such could be made and placed in the hands of every teacher, or this might be incorporated as a part of the manual of which I have spoken.

Then, too, the individual members must act as a committee of one to become acquainted with every other member. Do we appreciate acquaintanceship enough? We can get help for our personal work by brushing up against one another and exchanging views on this or that question. The conversation at such a meeting as this must necessarily be of the shop. I hope every one here will get acquainted with every one else before the conference is over.

The discussion of practical physics questions will be a great help to each of us. If you have questions you would like to have considered, send them to the secretary. Of course, it will be quite impossible to present them all at a general meeting, but they can be brought up in meetings of the Local Centers and the results reported at the next general meeting.

As to the Local Centers, they ought to be, and I might say they could advantageously be formed in all of the larger cities where instructors interested can get together four or five times a year for purposes heretofore named.

The question of an endowment to meet the expenses, which will surely come if the ideas already mentioned are carried out, is not a bad one. How it is to come is a question. We might have life members constituted by the payment of $50.00. If we could get enough, the question would be solved.

So much for some of the problems in the solution of which we may assist. But if our coming together in this territory is to encourage improvement in all interests centered in such a body, why not make it national in character? Why not invite all societies of kindred nature to unite with us their efforts so that they may all be centered upon one common interest—the better teaching of physics, other sciences and mathematics.

Dr. Henry S. Carhart, professor of physics in the University of Michigan, then delivered an address on "Revision of Physical Theory." This was published on page 371 of the January issue of this journal.

After the address lunch was served in the lunch room of the institute, at the conclusion of which the laboratories and shops of the institute were inspected.

At the beginning of the afternoon session the following communication was read by the secretary and referred to the executive committee:

Many science teachers of the Chicago and other high schools having expressed a desire for the organization of a "Central Association of Science Teachers," a preliminary meeting of teachers of each high school

science was called together by representatives of the Biology Round Table of the Chicago schools, by whom the subject had already been favorably considered.

All present spoke favorably of the need of such an organization and promised to bring it before their respective Round Table meetings. The physics teachers, having already formed a general organization, it was voted to bring the discussion of the advantages and purposes of an organization of *all* science teachers before the "Central Association of Physics Teachers" at their meeting on November 28.

The purpose of a general association of science teachers could be briefly stated as follows:

To promote the better teaching of all sciences in secondary schools, and to obtain the better correlation of the sciences to each other and to the general problem of education.

Some of the advantages of a *general* science association over the separate organization of each science are:

First—In "union there is strength," as shown by the success of the American Association for the advancement of Science, along the lines of which we would organize.

Second.—A larger attendance would be secured and so better railroad rates.

Third.—There would be section meetings for the consideration of subjects pertaining to each science, and general meetings for topics pertaining to the better correlation of the work.

A spring meeting in Chicago could be called for the first of April, when many schools have their spring vacation and Chicago schools are still in session. This would allow of the visiting of the laboratories. The first meeting could be set for Friday afternoon, at which a final organization might be perfected.

Will the Physics Association kindly take action on this communication, and appoint a committee to confer with teachers of the other sciences looking to this preliminary organization?

Mr. Ernest J. Andrews of the Robert A. Waller high school (Chicago) as chairman of the Committee on Current Events, presented the following report:

Mr. President and Fellow Members: Your committee on Current Events respectfully offers for your consideration the following report: We have perhaps taken some liberties with the words "current events," construing them more broadly than is usual. It has seemed best to leave to the ordinary periodicals the announcement of mere events, such as the deaths of scientists, the founding of science schools, or the like, as all such information is at the hand of every active physics teacher. And we have given attention to somewhat minor matters, which are, however, of special interest.

In the first place we find a large number of high schools are build-

ing at the present time; others are finished; and many are contemplated. Boston has recently completed four new buildings, all of the best character. Philadelphia has just dedicated its magnificent high school for boys, costing $1,533,000. Chicago has just completed a fine building and has two others well under way, one of which is to receive the historical name of McKinley. The high schools at Rochester, Omaha, New Haven, Des Moines, Syracuse and others will soon move into new buildings, and many are well under way, to be finished within a year.

This is very gratifying to all high school workers, in view of the fact that forty years ago high schools were fighting for existence, with but forty-five buildings in the United States. Today there are over 6,000, and the number is rapidly growing. But perhaps the most gratifying part is the perfection of the buildings and their equipments. The Philadelphia Central high school for boys, mentioned above, is the largest and finest high school building in the world; it will accommodate 2,400 pupils, and has an assembly hall which will hold 2,500 persons. It has a telescope, with a 15-inch lens, costing $30,000.

And when we come to the provisions which are making for science, and particularly for physics, it causeth the heart of the physics worker to rejoice. The newest Chicago building, perhaps, is typical of the provisions for physics in these new buildings that are springing up. In this building, which is the Robert A. Waller high school, six rooms are devoted to the physics department—the main laboratory, the lecture room, the shop, the dark room, a store room, and a private laboratory for the teacher, each of the rooms being fully sufficient in size and arrangement for the purpose intended. Some of the newer buildings, however, exceed this provision. Cambridge reports a separate laboratory for light and heat, one for mechanics, and one for electricity; New Haven has in the new building about the same.

Coming to equipment and apparatus, the new laboratories are improving on the old, and the old ones are constantly replacing old or inferior equipment for something better. The Chicago school mentioned above put in $2,500 for pupils' apparatus, and about twice as much for general equipment. It has a full shop outfit, hot and cold water, steam and gas, with electricity constantly at hand under pressures of 34 different electromotive forces ranging from 500 volts down to one volt, with specially devised switches for giving every desirable combination of cells or of lamp or other resistances, or combination of the various apparatus used, such as voltmeter, ammeter, battery rheostats, and the like, so that no time whatever is lost in making or changing combinations. It has a lecture room which will hold several classes, with optical lantern. This room may be darkened in twelve sections by a switch, which at the same time lowers the screen for use.

Compared with the little corner room with the surprising induction coil, which some of us enjoyed during our high school days, such pro-

visions seem marvelous. But some schools report even more, in some lines at least. The Central high school of Kansas City now has a shop equipment, a 7½ horse power direct motor, a 15-inch swing lathe, a 9-inch Barnes lathe, a 10-inch wood lathe, a saw bench, a jig saw, an emery grinder, a power grindstone, a polishing buff and a drill press, all of which are used solely for the construction and repair of apparatus. We think our honorable vice-president is to be envied.

All this calls for increased ability on the part of the physics teacher; he must have a thorough theoretical knowledge of the subject, and must be a machinist and electrical engineer scarcely inferior to the professional. In view of this the prerequisites of physics teachers are increasing. But it is not so with the perquisites. Because of the greater ability required, and particularly because of the increased expense of living, we have looked for some increasing of the schedules of salaries; but in vain. We have no report of any such increase recently.

Sometimes, when the physics teacher is struggling to repair some piece of broken apparatus, or is poring over the note book of some pupil who can neither cipher, spell nor write, a faint suspicion crosses his mind that all of this equipment, valuable as it is to the student, is a little hard on his own family, as the feeling is apt to creep in that his own salary is sacrificed for the equipment. Then it is he wends his weary way homeward, calls up his oldest son, and says: "Well, John, if you still yearn more for work than for study, go ahead; after all, it doesn't seem to pay to spend a decade in learning how to teach." And thus the schools lose another student and the country a teacher. It seems to be conceded that teachers are philanthropists, and they are willing to be philanthropists; but they sometimes feel as if they would like their charity to begin at home.

We find the tendency also is to devote more time to physics. Many schools report increased time, and only one a decrease. Milwaukee has reduced the time from seven periods per week to five. On the other hand Buffalo has increased this year from one-half year to one year. Baltimore and Cambridge now offer two years. The Chicago teachers hope soon to offer at least a year and a half. But perhaps the most encouraging report comes from St. Paul. There not only is the usual amount of physics offered, but also a course in electrical engineering and one in photography, both of which the teacher, Mr. Schmidt, reports as being very popular and valuable. They also offer a course in surveying, which in a way connects mathematics and physics, being offered as the last term in the four years' course in mathematics.

This combination of mathematics and physics brings us to the recent action of Mr. E. H. Moore of the University of Chicago. At the conference of the affiliated schools held at the university on November 8, he sought to bring about a closer relation between mathematics and physics, and is following that up vigorously, as we shall perhaps see this afternoon.

Every live teacher of either of the subjects, we think, will appreciate the need of this.

And in closing it will, perhaps, be interesting to speak of the discussion at the same conference at the university of Chicago in reference to changing the educational program of the public schools and colleges so as to give to the high school six years instead of four, two of which would be practically college years. If this should be brought about at any future time it would no doubt give to physics two years instead of one. And the value of our new laboratories which are being so generously provided, could then not be questioned.

Mr. E. C. Woodruff of the La Grange (Ill.) high school, chairman of the committee on a set of laboratory experiments, then read the following report:

The object of most reports heretofore presented on lists of laboratory experiments has been to suggest a minimum list of standard experiments that would cover the essentials of the subject and satisfy the average college-entrance requirements. The object of the list herewith offered is much more complex. It attempts:

1. To include the experiments mentioned in such "standard" lists.

2. To suggest a number of optional experiments, perhaps the maximum number for a general course, that will permit the teacher to extend his course to suit his particular desires or requirements and yet to keep within the bounds of the criteria to be mentioned below.

The criteria to be considered in making out such a list are as follows:

1. Experiments that should be performed by the teacher in class should not be used in the laboratory under the impression that the pupils will gain anything by performing them themselves.

2. Experiments in which the normal teacher cannot arouse the interest of the normal pupil should be omitted. By such are meant experiments that the pupil is liable to stigmatize as "trifling" either because his previous experience enables him to go through all the operations in imagination more quickly and even more efficiently than in actuality, or because the operations and results are so obvious and simple that the mere recital thereof is sufficient.

3. Experiments that do not fulfill at least two of the requirements mentioned below should be omitted.

The essential requirements under which an experiment becomes eligible for consideration are:

1. The experiment should have a stimulating effect on both pupil and teacher.

2. Some general law may be quantitatively illustrated.

3. The experiment may have a direct bearing on the solution of some numerical problem.

4. The experiment may give the pupil an insight into and an in-

tertest in some phenomenon of his environment outside of his school life.

5. There may be some training in method and technique.

It is thought that the list herein submitted:

1. Includes all the experiments that fulfill the above requirements and that are at the same time possible in the laboratory of a secondary school.

2. Possesses sufficient scope and flexibility to fit the needs of both the brightest and the most mediocre pupil.

3. Has the experiments listed in an order especially logical and suggestive.

The experiments are lettered according to difficulty, A, B, C. The A's are those each one of which may be performed by each pupil. Of the B's each pupil may perform about 50 per cent, elected according to their individual interests or needs. Of the C's the better pupils may be permitted to elect a limited number after having satisfied the requirements in the other groups.

Many of the references for some of the B and C experiments are a little unsatisfactory in that they do not treat the experiments in as full or precise a way as is desirable for optional extended work or even for work of what might be called "standard" grade. The number of experiments that fall under this head is about 20, besides those for which there are no references. As samples of such are numbers 9, 14, 20, 23, 66, 60, 63.

Many of the experiments listed are original with members of the committee and their friends and as yet are not accessible in print. But of these some are now appearing in various magazines. However, the mere enumerations of the title will no doubt be suggestive to the teacher who wishes to plan for better things. Stewart & Gee's "General Processes" and Perry's "Mechanics" will be of value in these cases. Any questions about the list will be very welcome at any time.

Number.	N. S. & T.	Ayres.	Chute.	Adams.	MECHANICS:	
					METRIC SYSTEM.	
		1	11			
1	1	2	16		Metric rule	A
2	6	9	22	22	Balance and burette	A
3	3	4	14	3	Micrometer caliper	A
4	2	5	13	2	Verniered caliper	A
5					Spherometer	B
					STRENGTH OF MATERIALS.	
6	17	14	26		Tensile strength of wires, etc.	A
					ELASTICITY.	
7	15	16		4	Hooke's law and Jolly's balance	A
8	14	15			Hooke's law and Young's modulus by stretching.	A
				8		
9	13	17		9	Hooke's law and laws of flexure	B
10	16	18			Hooke's law and laws of torsion	B
					FORCES AND MACHINES.	
11	21	19	32	11	3 parallel forces in equilibrium	A
12	22	20	30	10	3 non-parallel forces in equilibrium	A
	23	21				
	24					
13	26	22	36	12	Levers.	A
14	28	23	37		Pulleys and forces at various angles	A
15					Simple crane	A
16					Guyed crane	B
17					Simple and differential windlass	A
18					Open and closed manometers	A
19				16	Inclined plane	A
					MOTION:	
					UNIFORMLY ACCELERATED MOTION:	
20	19		34		Galileo's method	B
21					Atwood's machine	B
22				13	Freely falling body [S. & G., No. LIII.]	BC
					SIMPLE HARMONIC MOTION:	
		27		14		
23	20	28	35	15	Simple pendulum	A
24			33		Conical pendulum for curvilinear motion	B
25					Torsional pendulum	C
26					Inclinable pendulum for g	B
27					Horizontal pendulum for period and force	C
28					Longitudinal vibrations in springs	C
29					Torsional vibrations in springs	C
30					Flat spring vibrating in its own plane	C
					FRICTION:	
31	30	26			Sliding friction	A
32		26			Friction on various roads	B
33					Friction in liquids [by means of siphon.]	C

Number.	N. S. & T.	Ayres.	Chute.	Adams.		
					FLUIDS: GASES:	
		30	44	21	**BOYLE'S LAW:**	
34	35				"Guthe & Miller" form	A
35					"Michigan method" C. & C. p. 138	A
					CHARLES' LAW:	
36	66	41	65	31	Coefficient with constant pressure	A
37		42			Coefficient with constant volume	B
38					Specific gravity of gases	C
39	32			20	Verniered barometer	A
					LIQUIDS:	
					ARCHIMEDES' PRINCIPLE.	
	37					
40	39	31	46	23	For a body heavier than water	A
	38					
41	39	47			For a body lighter than water	A
42	40	32	48	24	Specific gravity of bodies heavier than water	A
43	42	33	49	25	Specific gravity of bodies lighter than water	A
	41		50			
	43					
44	47		55		Specific gravity of bodies by using the Jolly balance	A
					SPECIFIC GRAVITY OF LIQUIDS.	
45	46	34	53	26	Sinker method	A
46	44	35	52	27	Bottle method	A
47	50	37			Hydrometer method	A
48	49	36		28	Hare's method	A
49	48		54		By balanced columns of 2 liquids	A
50	51		51		Specific gravity of soluble substances	A
					SOUND:	
	114		104			
51	115	69	108	57	Wave length by resonance	A
52					Melde's experiment to demonstrate all the laws of strings, Tyndall, pp. 139-143	B
53	118	68		56	Tuning fork graphics	B
	119	71		53		
				54		
54	120	72	111	55	Sonometer work	B
55					Velocity of sound: In air (direct, reflected); In R. R. track	C
56	109				Ripple trough work	C
57	121	70	105	58	Kundt's method for velocity in solids	C
58			107		Interference experiments	C
					LIGHT:	
					REFLECTION:	
		75	117	61		
59	126	76	119	62	Plane mirrors	A
		77	120			
		78	to	63		
60	127	79	125		Curved mirrors, cylindrical and spherical	A
					REFRACTION:	
61	128		126	70	Index from air to water	A
62	129		127		Index from air to glass	A
			128	64		
			129	to		
			132			
63	130	80	134	69	Converging lenses	A
		83		71		
64		84	118	72	Angles and index of a prism	B

Number.	N. S. & T.	Ayres.	Chute.	Adams.		
					APPLICATIONS:	
65	131	82	130		Model of telescope and compound microscope....	A
66		82			Magnifying power of a telescope	A
67					Exploration of a curved surface.....	C
68					Dividing engine measurements	B
69					Weighing with optical balance	B
70					Work with optical lever [S. & G. XVI.].....	C
			115	59		
71	125	74	116	60	Photometric work	B
	57					
					HEAT:	
72	58	38	58	29	Thermometric fixed points	A
73	59	43	66		Melting points of solids	A
74	64	39	63	30	Expansion coefficient of solids	A
75	67	46	73	33	Latent heat of fusion of ice	B
76	68	47	74	34	Latent heat of vaporization of water.....	B
		44				
77	69	45	70	32	Specific heat of solids	B
78	70		71		Specific heat of liquids by rate of cooling.....	C
79					Latent heat of fusion by rate of cooling.....	C
					MAGNETISM:	
	71	48		25		
	to			to		
80	80	49	75	28	General magnetic work	A
81					Magnetic exploration of a room, (for poles).....	A
82					Exploration of a magnetic field with a Jolly balance	B
83					Exploration of a magnetic field by vibrational methods	B
					ELECTRICITY:	
83	87	50	84	39	Simple voltaic cell	A
84	89	50	85	41	Action of a current on a magnetic needle.....	A
85	90			40	Helices and electro-magnets	A
86	88				Electrolysis of Cu S O, and of K I.....	A
87	91				Effect of resistance in a circuit	A
88	92				Effect of a magnet on a galvanometer	A
89	93		86	42	An electromotive series	A
90	95	65	93	46	Battery grouping	A
91	96	56	89		Resistance by substitution	A
		57				
		58		47		
					Measurement of Resistances.	
92	98	59	90	48	Slide bridge | singly, in series, and in parallel...	A
93	102	60			Effect of temperature on resistance	B
94					Resistance of Electrolytes	B
	104	51	94	43		
		52				
95	106	53	95	44	Galvanometer calibration	C
96					Instrument assembling, galvanometers, motors, etc.....	B
97					Manufacture of Resistances	C
98					Condenser methods for E. M. F.....	C
99				49	Potentiometer methods for everything	C
100					Testing dynamos, motors, lamps, relays, etc....BC	

The printed program contained a list of eleven topics to be discussed informally. Lack of time permitted of the discussion only of the following:

How much setting up of apparatus should the pupil / teacher do?

Should laboratory directions be very explicit as to how the experiments are to be carried out, or should the pupil be left largely to himself as to the mode of performing an experiment?

Leader, director, co-worker, inspector, information bureau, policeman, spectator—which is the teacher's chief function during the laboratory period?

Why is it that students come to us with insufficient mathematical preparation for their physics?

Would it be possible to organize the subject matter of algebra, plane and solid geometry and physics into a thoroughly coherent four years' course?

The laboratory method of instruction: What are its essential elements? Is it applicable to mathematics?

The discussion was lively and interesting and that of the first three topics showed that there was considerable difference of opinion and variation of practice. The discussion of the topics concerning the correlation of mathematics and physics teaching showed that all participating in it were of the firm belief that this correlation should be much closer and thoroughgoing than is at present the case. Several prominent mathematical teachers who were present expressed themselves as heartily in sympathy with any movement which would tend to introduce more of the laboratory method into the teaching of mathematics. On special motion the executive committee was directed to arrange for a conference with the mathematics teachers of Chicago and its vicinity whereby more definite action might be taken. [This conference met December 15, at Chicago, and appointed a committee consisting of Messrs. P. B. Woodworth (Lewis Institute), E. H. Moore (University of Chicago), C. E. Linebarger (Lake View high school), C. R. Mann (University of Chicago) and E. C. Woodruff (La Grange high school), to draw up a definite course in laboratory mathematics for secondary schools, the same to be presented at the spring meeting of the association.]

After the adjournment of the afternoon meeting the members participated in an excursion to the power house of the Metropolitan West Side Elevated Railway Co., and the Harrison street plant of the Edison Electric Co., assembling at 7 P. M. at Kinsley's restaurant for the banquet.

The following toasts were responded to: *Physics and Invention*, by Mr. J. E. Armstrong, principal of the Englewood (Chicago) high school; *The Relations of Physics and Medicine* (see page 443 of this number), by Dr. Winfield Scott Hall, professor of physiology, Northwestern University Medical School; *Physics and Machines*, by Mr. Rob-

ert Hall Wiles, mechanical expert; *Physics and Mathematics*, by Mr. E. H. Moore, head professor of mathematics, University of Chicago; *Physics and Engineering*, by Mr. S. G. McMeen, chief engineer, switchboard department, Western Electric Company; *Physics and Visions*, by Mr. A. A. Upham, department of physical science, Whitewater (Wis.) normal school.

All day Saturday, November 29, was given up to an excursion to the Illinois Steel Company's works, the Chicago Ship Building Company's yards and the works of the American Smelting and Refining Company.

Reported by C. E. LINEBARGER.

Correspondence.

EDITOR SCHOOL SCIENCE:

Dear Sir—Personally, I should like to see something on laboratory work in physiography given in SCHOOL SCIENCE. I am interested in this line and would like to compare notes with others.

The following has proved enjoyable in our work in biology: Once a week we discuss the life of a great scientist. Pupils are notified the preceding week who is "up" for discussion and are asked to go to the reference library and read a short sketch of the man's life. Then we talk very informally of the period in which he lived, of his own life, books, work, etc., and try to see what he has done for the world.

Pupils who hand in a brief set of notes from their reading are given credit for this, as for any other work. It was originally planned to take up each scientist on his birthday and call the exercise "biological birthdays," but this order was found to be inconvenient.

Grand Rapids, Mich. GRACE F. ELLIS.

Mathematical Supplement of School Science

A Quarterly Devoted to the Interests of Secondary Mathematical Teaching.

The mathematical teaching in secondary schools of the future will be based much more largely than is now the case on the conception of mathematics as the abstract form of the metrical sciences. This is believed to be true because in the large number of test cases in which methods of teaching have been based upon this conception, results have been markedly superior to those of any other method, whether measured by the standards of either pure or applied mathematics.

SCHOOL SCIENCE, through its MATHEMATICAL SUPPLEMENT, to begin in April, hopes to be instrumental in promoting the trying-out process through which this method must pass before its general adoption. Those who have attempted teaching by this method and have results worth reporting to others interested, are invited to forward their results in the form of short articles to the mathematical editor.

The SUPPLEMENT does not contemplate a close drawing of the lines of pedagogical creed, but wishes especially to assist in improving the teaching of mathematics for its uses in a broad sense. By this is meant the uses of mathematical principles in science, industry and even in advanced mathematics. The great *desideratum* we would assist in realizing is a firm grasp of mathematical truth and method on the part of the student.

The following men—some of them of international reputation as teachers—will be among the early contributors to the SUPPLEMENT: Professor E. H. Moore, Professor C. R. Mann and Mr. A. C. Lunn, of the University of Chicago; Professor W. W. Beman, of the University of Michigan; Professor N. C. Ricker,

dean of the College of Engineering, University of Illinois; Professor E. W. Davis, of the University of Nebraska; Professor David Eugene Smith, of Teachers' College, N. Y., and Dean W. S. Jackman, of the School of Education, University of Chicago. All these men have made a careful study of the problems of secondary mathematical teaching and will have something to say of great value to all interested in the improvement of mathematical teaching.

SCHOOL SCIENCE, with its MATHEMATICAL SUPPLEMENT, is the only journal in English devoted exclusively to the teaching of science and mathematics in the secondary school. Covering both fields as it does, the opportunity for exhibiting the organic relation between mathematical and science courses is peculiarly favorable. In addition to its leading articles it will contain timely editorials, book reviews, round table talks, reports of meetings, notes of progress, correspondence, etc.

The SUPPLEMENT will be furnished regular subscribers of SCHOOL SCIENCE at no increase in the journal's subscription price ($2.00). The SUPPLEMENT will also be issued separately in April, June, October and January; its price is 15 cents a copy or 50 cents a year.

Subscribers are requested to call the attention of mathematics teachers to the SUPPLEMENT.

Direct all mathematical correspondence to

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